

Feasibility Plan for Maximum Truck to Rail Diversion in Virginia's I-81 Corridor

final report

prepared for the

Commonwealth of Virginia

prepared by

Cambridge Systematics, Inc.

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Executive Summary

■ Purpose of this Study

The primary objective of this report is to comply with the requirements of Virginia's 2007 Appropriations Act, Item 442, which calls for: "development of a feasibility plan to define the conditions that would be necessary to divert the maximum amount feasible of the long-haul, through-truck freight traffic to intermodal rail in the Interstate Route 81 Corridor." It follows and expands on several prior studies of the issue, including:

- *Desirability and Feasibility of Establishing Additional Intermodal Transfer Facilities* (2001);
- *The Potential for Shifting Virginia's Highway Traffic to Railroad* (2001);
- *The Northeast-Southeast-Midwest Corridor Marketing Study* (2003); and
- *The I-81 Corridor Improvement Study* (2007).

■ Current and Future Freight Activity in the I-81 Corridor

According to year 2008 Commonwealth vehicle counts, I-81 carried an average of 39,730 vehicles of all types and 9,284 trucks per day in both directions, based on averages of individual segment counts. I-81 has the highest truck percentage, and carries the second-highest number of trucks, of any major route in Virginia. Truck origin-destination surveys were performed in year 2007 at the two truck weigh stations on I-81, and determined that around 62 percent of trucks surveyed were passing through Virginia; 41 percent of these used I-81 alone, and 23 percent used I-81 in combination with other routes (I-77, I-495/I-95, I-66, et al.). Around 32 percent of I-81 trucks were moving between other states and Virginia, and around 6 percent were moving between origins and destinations within Virginia. In 2008, I-81 handled nearly 3.4 million trucks; by the year 2035, I-81 is expected to handle 7.1 million trucks.

There are two primary rail routes paralleling I-81 – the Piedmont Line and the Shenandoah Line. Both are owned and operated by the Norfolk Southern Rail Road (NS). Within Virginia, the Shenandoah Line runs northeast from the Tennessee state line to the West Virginia state line; the Piedmont Line runs northeast from the North Carolina state line, reaches Manassas, and then heads west to join the Shenandoah Line at Riverton Junction near Front Royal. Both routes are single-track, with additional tracks in various locations to allow trains moving in opposing directions to pass each other. The railroad handles both intermodal traffic (international shipping containers and "dry van" truck

bodies on chassis) and non-intermodal traffic. In 2006, the two lines handled around 140 intermodal trains and 490 non-intermodal trains per week. Non-intermodal traffic is expected to remain constant, while intermodal traffic is projected to grow from 500,000 units in 2006 to 1.1 million units by 2035, based on natural market growth independent of truck to rail diversion efforts.

■ Strategies to Achieve the Maximum Feasible Truck to Rail Diversion

Truck origin-destination surveys were performed in year 2007 at the two truck weigh stations on I-81, and the results of those surveys were used to classify the year 2008 truck counts according to the particular type of truck movement. Starting with 9,284 trucks per day, trucks were eliminated from further consideration as diversion candidates if they were traveling between origins and destinations that are not easily served by rail, or if they were carrying commodities that are not considered divertible to rail. The remaining trucks were classified according to: the type of move they were making, the distance they were traveling, and importantly, the type of intermodal transfer technology necessary to divert them to rail. Conventional intermodal transfer technology lifts intermodal containers and dry van truck bodies onto and off of railcars, but an alternative technology – known as “open technology” – rolls truck bodies onto and off of railcars, allowing non-intermodal truck types to be carried on rail.

Table ES.1 Potentially Divertible I-81 Trucks by Distance and Technology

	Trucks Per Day With Divertible Routing and Divertible Commodity	Potentially Divertible With Conventional Technology		Potentially Divertible With Open Technology	
		Over 500 Miles	Under 500 Miles	Over 500 Miles	Under 500 Miles
I-81 Through Virginia	3,190	2,127	-	1,063	-
I-81 and Other Routes Through Virginia	1,652	1,082	19	541	10
I-81 to and from Virginia	2,156	310	1,128	155	564
I-81 Entirely within Virginia	-	-	-	-	-
Total	6,998	3,519	1,147	1,759	573

Today, there is both truck and rail service in the I-81 corridor. Some shippers' needs are better met by rail than by truck; other shippers' needs are better met by truck than by rail.

If rail can offer improved cost, reliability, and speed versus trucking, then some share of trucks could be expected to divert to rail. However, a reasonable analyst would never expect that **all** trucks potentially capable of diverting to rail would actually do so. This would require banning trucks from the I-81 corridor entirely, or heavily subsidizing rail to the point where its cost advantage becomes completely insurmountable, and neither is considered a feasible strategy. It is, therefore, appropriate to reduce the number of potentially divertible trucks by some amount, to reflect the competitive balance between trucking and rail – but by what amount, and based on what reasoning? The answers vary, because there is no “one-size-fits-all” strategy to achieve truck to rail diversion.

Based on Table ES.1, it is easy to see that the truck to rail diversion opportunity for I-81 actually consists of multiple opportunities – some long-haul and some short-haul, some passing through Virginia and some moving freight to and from Virginia, some utilizing conventional technology and some requiring open technology. These varied opportunities require different infrastructure and rail service strategies to achieve the maximum feasible diversion. Five basic strategies were identified.

- Strategy #1 envisions that the Piedmont and Shenandoah lines in Virginia would be improved to handle additional intermodal trains as well as longer trains; that complementary network improvements would be made in other states throughout the eastern and southeastern U.S. to match the capacity of these lines; and that key rail terminals would be upgraded or developed in other states to handle additional traffic. Intermodal rail terminals would operate in a “conventional” manner, using existing lift-on/lift-off equipment to transfer freight from truck to rail; and trains would operate at “conventional” speeds, meaning speeds currently typical for freight trains on the Piedmont and Shenandoah lines. NS has already proposed to improve conventional intermodal service over these lines as part of its multistate “Crescent Corridor” program. Strategy #1 is aimed at the diversion of long-haul intermodal traffic passing through Virginia.
- Strategy #2 is envisioned as a direct follow-on to implementation of the Crescent Corridor. Each Crescent Corridor intermodal hub would be upgraded with open technology capabilities and appropriate rail equipment. Some additional line improvements also might be needed, although it is hoped that most of what is needed will be provided as part of the Crescent Corridor program. Open technology would operate at the same average speeds as other freight on the Piedmont and Shenandoah lines (around 30 mph). Strategy #2 is aimed at the diversion of long-haul non-intermodal traffic passing through Virginia.
- Strategy #3 is envisioned as a direct follow-on to Strategies #1 and #2, and introduces service through two intermodal terminals in Virginia that are potentially accessible to the Crescent Corridor: the existing terminal at Front Royal (the Virginia Inland Port), which handles traffic to and from Virginia Port Authority terminals in Hampton Roads; and the planned facility at Elliston (near Roanoke), which is to be developed as part of the Heartland Corridor. Under Strategy #3, these hubs would be upgraded and enhanced to accommodate both intermodal and open technology traffic handled along the Shenandoah Line (in the case of Elliston)

and both the Shenandoah and Piedmont lines (in the case of Front Royal). Strategy #3 is aimed at the diversion of long-haul intermodal and non-intermodal traffic with an origin or destination in Virginia.

- Strategy #4 is envisioned as a direct follow-on to Strategies #1, #2, and #3, and involves upgrading the Shenandoah line and connecting lines in Tennessee and Pennsylvania, to accommodate open technology train service at average service speeds of 60-70 mph. With Virginia rail hubs at Front Royal and Roanoke, the higher-speed service network should extend at least as far south as Knoxville, and at least as far north as Harrisburg and possibly Bethlehem. The speed improvements would require extensive double-track and passing track construction, and probably geometric improvements as well. Strategy #4 would target three market opportunities: short-haul (less than 500 miles) intermodal and non-intermodal trucks passing through Virginia or with an origin or destination in Virginia; additional diversion of long-haul trucks moving between the Knoxville and Harrisburg markets; and an overnight shuttle or “sleeper service” to any trucks moving in the Knoxville to Harrisburg corridor via I-81.
- Strategy #5 could be implemented alongside Strategies #1 through #4, or it could be implemented as a stand-alone strategy independent of any other improvements. It aims to establish a very high-speed (perhaps 120 mph) open technology service between Knoxville and Harrisburg. Such a service might potentially attract intermodal and non-intermodal trucks that are passing through Virginia using I-81. These trucks could be “intercepted” (arriving trucks would hand off cargo to the railroad, and different trucks would pick up the freight at the other end of the line) or “shuttled” (arriving trucks and their drivers would be carried from one end of the line to the other, like a ferry boat on land). This would require a new dedicated high-speed double-track rail corridor. Strategy #5 targets long-haul intermodal and non-intermodal trucks passing through Virginia using I-81 only.

Table ES.2 Strategies to Divert Trucks to Rail

Target Opportunity	Potentially Divertible Trucks Per Day (2008), From Table ES-1	Strategy to Divert Trucks to Rail
Long-haul (500+ miles) intermodal trucks moving through Virginia on I-81 only, or on I-81 in combination with other routes	2,127 + 1,082 = up to 3,209	#1: Expand <u>conventional intermodal</u> rail terminals, network capacities, and services.
Long-haul (500+ miles) non-intermodal trucks moving through Virginia on I-81 only, or on I-81 in combination with other routes	1,063 + 541 = up to 1,604	#2: Introduce <u>multistate network of open technology terminals</u> with conventional speed services, after implementing Strategy #1.

Long-haul (500+ miles) intermodal and non-intermodal trucks with an origin or destination in Virginia	310 + 155 = up to 465	#3: Develop and enhance <u>Virginia intermodal and open technology terminals</u> , after implementing Strategy #1 and #2.
Short-haul (less than 500 miles) intermodal and non-intermodal trucks, passing through Virginia or with an origin or destination in Virginia; plus opportunity to capture additional long-haul trips between the Knoxville and Harrisburg markets; plus the opportunity to offer an overnight shuttle or “sleeper service” to trucks in this corridor	19 + 10 + 1,128 + 564 = up to 1,720 (short haul only) up to 4,910 (short and long haul)	#4: Introduce <u>higher-speed open technology</u> service in the Harrisburg-Knoxville Corridor, after implementing Strategies #1, #2, and #3.
Long-haul (500+ miles) intermodal and non-intermodal trucks moving through Virginia on I-81 only; these would be trucks arriving at key “cordon” points	2,127 + 1,063 = up to 3,190	#5: Introduce very high-speed open technology <u>“truck intercept/truck shuttle” service</u> through Virginia Option 5A: implement along with other strategies Option 5B: implement as “stand alone”

Each strategy was evaluated separately and estimates of its maximum feasible diversion, cost, and overall feasibility were prepared. Strategies #1 and #5B can be developed independent of any others, but Strategies #2, #3, #4, and #5A depend on the implementation of preceding strategies. It is therefore necessary to evaluate the diversion opportunities in terms of programs that represent combinations of strategies. Estimates of units diverted in Virginia and capital construction costs incurred in Virginia are summarized below. Cost figures reflect total expected capital construction costs for investments within Virginia, in current dollars, without inflation or discounting or cost of funds adjustments. Funding to meet these costs would have to be drawn from some combination of private railroads, the Federal government, the Commonwealth, and users.

- **Strategy #1 alone** diverts 13.5 percent of I-81 trucks, estimated at 19.1 million units through 2035, at a Virginia-only capital construction cost of \$512 million, or \$26.82 per unit. Total capital cost including other states is estimated at \$2.1 billion. This strategy is considered feasible.
- **Strategies #1 and #2** divert 20.3 percent of I-81 trucks, estimated at 28.6 million units through 2035, at a Virginia-only capital construction cost of \$762 million, or \$26.61 per unit. Total capital cost including other states is estimated at \$2.675 billion. This program is considered potentially feasible.
- **Strategies #1, #2, and #3** divert 22.8 percent of I-81 trucks, estimated at 32.2 million units through 2035, at a Virginia-only capital construction cost of \$862 million, or

\$26.78 per unit. Total capital cost including other states is estimated at \$2.775 billion. This program is considered potentially feasible.

- **Strategies #1, #2, #3, and #4** divert 29.9 percent of I-81 trucks, estimated at 42.2 million units through 2035, at a Virginia-only capital construction cost of \$2.1 billion, or \$50.07 per unit. Total capital cost including other states is estimated at \$4.275 billion. The feasibility of this program is unknown, primarily because the market's acceptance of Strategy #4 cannot be determined without extensive further research. For this study we have allowed that Strategy #4 might have very high rates of market capture, but even so it has a capital cost of \$125.00 per diverted unit, compared with less than \$27.00 per diverted unit for Strategies #1, #2, and #3.
- **Strategies #1, #2, #3, #4, and #5A** divert 37.7 percent of I-81 trucks, estimated at 53.3 million units through 2035, at a Virginia-only capital construction cost of \$9.1 billion, or \$171.09 per unit. Total capital cost including other states is estimated at \$13.275 billion. The feasibility of this program is unknown -- further market research, engineering, and environmental work is needed.
- **Strategy #5B alone** diverts 17.2 percent of I-81 trucks, estimated at 24.3 million units through 2035, at a Virginia-only capital construction cost of \$7.0 billion, or \$288.55 per unit. Total capital cost including other states is estimated at \$9.0 billion. The feasibility of this program is unknown -- further market research, engineering, and environmental work is needed.

Table ES-3. Benefits and Costs from Combinations of Strategies

	1 Only	1+2	1+2+3	1+2+3+4	1+2+3+4 +5A	5B Only
Potentially Divertible Trucks	3,209	4,813	5,278	6,998	6,998	3,190
Long-Haul through Trucks Diverted	1,255	1,883	1,883	2,368	3,097	1,595
Other Trucks Diverted	-	-	233	405	405	-
Total Trucks Diverted	1,255	1,883	2,116	2,773	3,502	1,595
Long-Haul through Trucks on I-81	5,711	5,711	5,711	5,711	5,711	5,711
Total Trucks on I-81	9,284	9,284	9,284	9,284	9,284	9,284
Total AADT on I-81	39,730	39,730	39,730	39,730	39,730	39,730
Share of Potentially Divertible Trucks Diverted	39.1%	39.1%	40.1%	39.6%	50.0%	50.0%
Share of Long-Haul Through Trucks Diverted	22.0%	33.0%	33.0%	41.5%	54.2%	27.9%
Share of Total Trucks Diverted	13.5%	20.3%	22.8%	29.9%	37.7%	17.2%
Share of Total AADT Diverted	3.2%	4.7%	5.3%	7.0%	8.8%	4.0%
Annual Units Diverted, 2008	458,075	687,295	772,340	1,012,319	1,278,117	582,175
Annual Units Diverted, 2035	965,496	1,448,629	1,627,881	2,133,690	2,693,920	1,227,065
Total Units Diverted, 2008-2035 (Millions)	19.1	28.6	32.2	42.2	53.3	24.3
Projected Cost Total (\$ Millions)	2,100	2,675	2,775	4,275	13,275	9,000
Projected Cost in Virginia (\$ Millions)	512	762	862	2,112	9,112	7,000
Cost in Virginia per Unit Diverted (\$)	26.82	26.61	26.78	50.07	171.09	288.55
Assessment of Feasibility	Feasible	Potentially Feasible		Feasibility Unknown		

Figure ES-1. Comparison of Truck to Rail Diversion Percentages

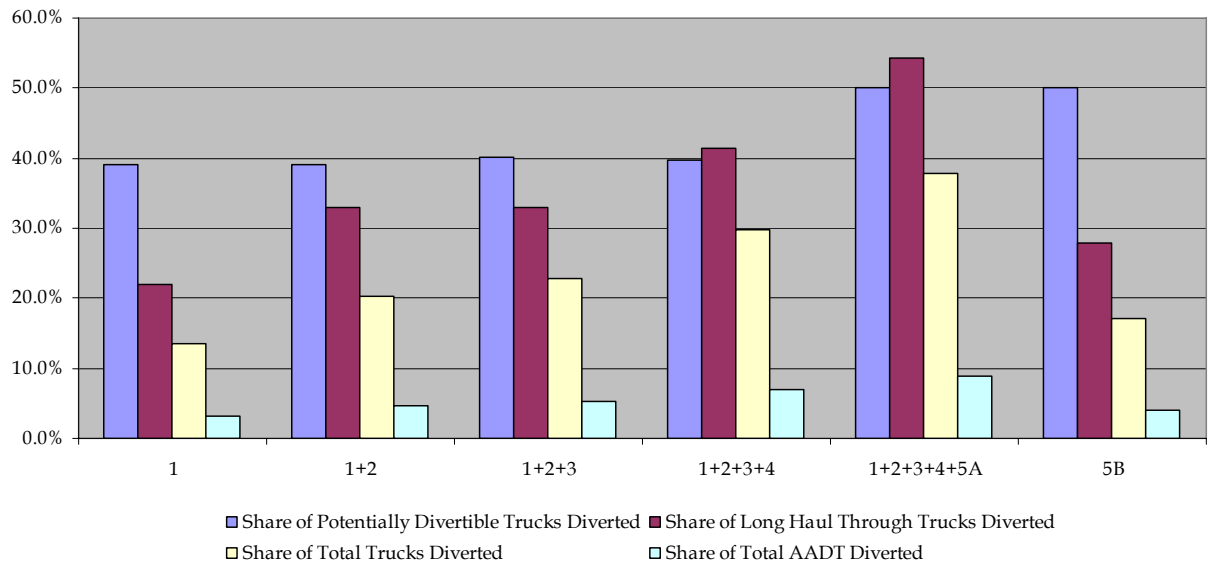


Figure ES-2. Total Units Diverted Through 2035 and Capital Costs in Virginia

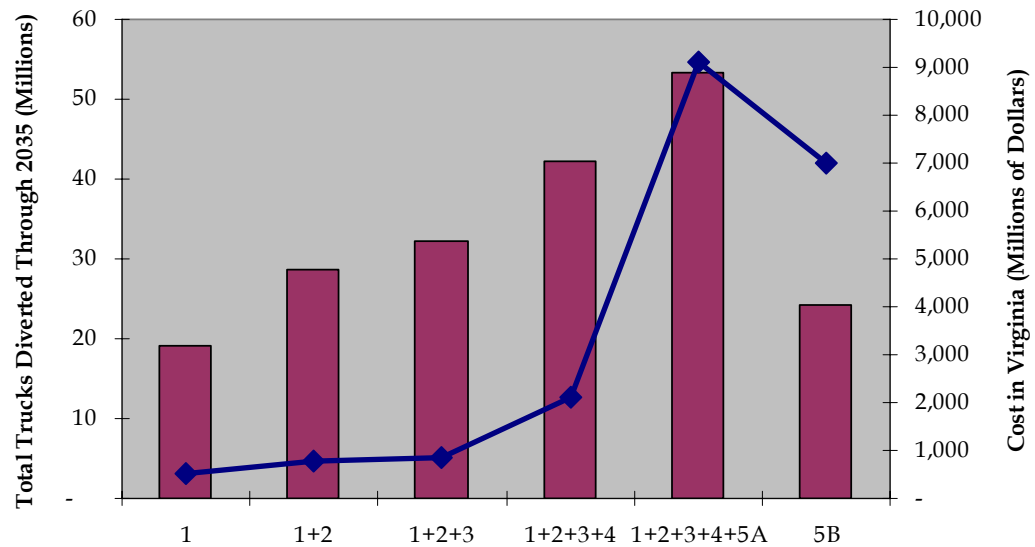
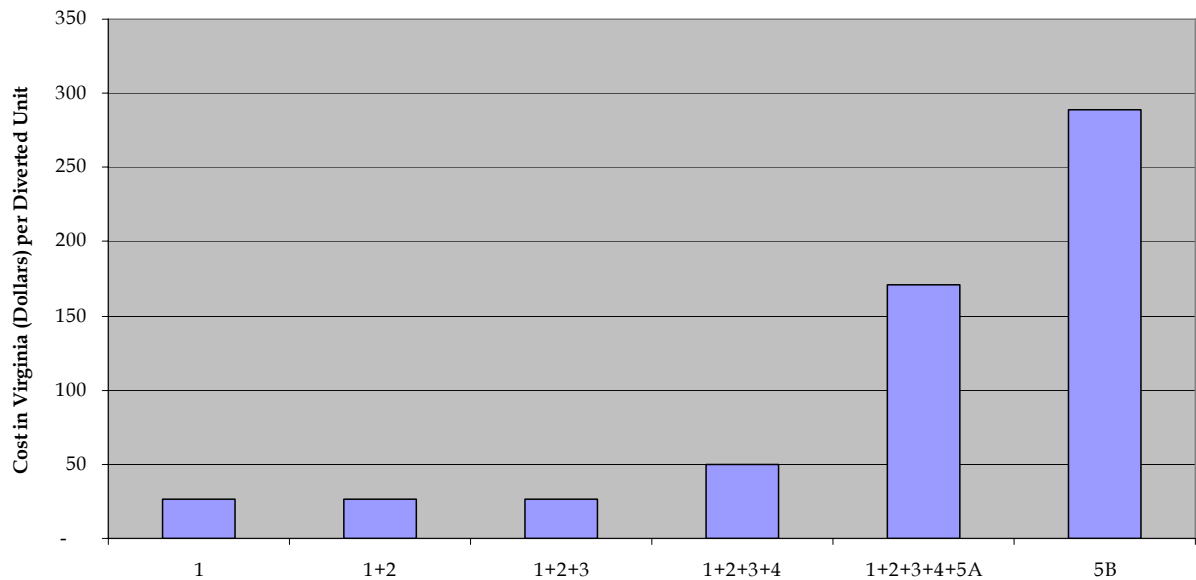


Figure ES-3. Cost in Virginia per Diverted Unit Through 2035

From among these choices, the preferred strategy may vary depending on which decision factor is most important. For example, Strategies #1 through #5A combined provide the highest truck to rail diversion, but at 7 times the cost per unit of Strategies #1 through #3 combined. No strategy, or combination of strategies, would divert more than 54 percent of long-haul through trucks, or 38 percent of total trucks, on I-81.

■ Recommendations and Action Plan

This report recommends pursuing each of these strategies, but in different ways.

- Strategy #1 (improve conventional intermodal rail) is the most feasible, and there is an active proposal (the Crescent Corridor) to accomplish the targeted diversion. It is the lowest-risk strategy and one of the least expensive on a per unit diverted basis. The Commonwealth should continue to participate in the investigation and advancement of this concept.
- Strategies #2 (develop multistate open technology network) and #3 (develop and enhance Virginia terminals) are considered potentially feasible. From a technical and engineering standpoint the required improvements are achievable, but as service strategies they are by no means proven, and there are no active plans to implement them. They are inexpensive on a per unit diverted basis. NS should continue research of these strategies to increase truck to rail diversion over and above what can be accomplished using Strategy #1 alone.

- Strategy #4 (higher-speed open technology service) and Strategy #5 (very high-speed truck intercept/truck shuttle service) would further increase the truck to rail diversion potential. However, the feasibility of these strategies from a technical, market, and financial standpoint is currently unknown, and would require extensive and potentially costly follow-on studies to determine with specificity. Additionally, the anticipated capital cost in Virginia per diverted unit is quite high -- \$175 per unit for Strategy #4 and \$288 per unit for Strategy #5 -- compared to less than \$27 per unit for Strategies #1, #2, and #3. Further investigation of these concepts may be warranted, but should be a lower priority than advancement of the more proven and cost-effective strategies identified in this report.

The recommended action plan to achieve the maximum feasible truck to rail diversion in Virginia's I-81 corridor can be summarized as follows:

- **RECOMMENDATION #1: Advance the Crescent Corridor.** The Commonwealth should proceed with further investigations of potential participation in the Crescent Corridor project. These should include: evaluation of the Commonwealth's financial participation; structures to ensure successful investments by other states and the private sector; necessary environmental studies; and agreements to ensure that the expected diversion benefits are actually delivered.
- **RECOMMENDATION #2: Investigate other potentially feasible truck to rail diversion strategies.** NS should proceed with further development of strategies to improve upon the diversion achieved by the Crescent Corridor, particularly from: a) conventional speed open technology service to divert long-haul bulk trucks; and b) potential private investments in Virginia terminals to divert Virginia origin-destination traffic.
- **RECOMMENDATION #3: Continue to advance improvements identified in the I-81 Tier I EIS.** The EIS estimated a maximum diversion of 1,224,500 units in 2035; this study finds that it is feasible divert 965,496 annual units in 2035, and potentially feasible to divert up to 1,627,881 units. The difference between the diversion estimate in this report and the diversion estimate in the EIS represents slightly more than two years of normal growth in the total number of I-81 trucks, which is not considered significant.

1.0 Introduction

■ 1.1 Freight Movement in Virginia

As noted in the *Virginia Statewide Multimodal Freight Study*, freight movement is a critical issue for the Commonwealth, for a variety of reasons:

- Freight movement is essential to Virginia's overall economy.
- Many Virginia industries are highly dependent on freight movement for their business operations.
- Efficient freight movement benefits Virginia's residents.
- The benefits of freight movement are not delivered without costs.
- Much of Virginia's freight transportation system is operating at a high level of efficiency and performance, but there are critical physical and operational chokepoints throughout the system.
- Virginia freight tonnage is projected to double over the next 30 years.
- Addressing freight chokepoints requires public sector actions to change private sector behaviors.
- With growing transportation system needs for both passengers and freight, and with rising project costs and limited funding, the Commonwealth needs to be especially careful to ensure that its freight investments are structured to deliver the maximum "return on investment."
- Changes in the freight movement industry are forcing the public sector to embrace next-generation transportation planning strategies.
- "Freight happens." The challenge from a public perspective is how to plan actively to guide and accommodate freight movement in a way that minimizes public burdens while maximizing public benefits.

■ 1.2 The I-81 Corridor: Challenges and Opportunities

I-81 carries some of the highest truck percentages and volumes in the Commonwealth. Looking ahead, I-81 vehicle volumes are growing and highway performance is projected to decline, such that highway improvements are needed.

Numerous studies have determined that a large share of truck traffic on I-81 is long-haul traffic passing through the Commonwealth, moving between other states. I-81 is generally paralleled by two freight rail lines. Both are owned by the Norfolk Southern Railway; one is in the Shenandoah Valley, the other is further east in the Piedmont. I-81 can, therefore, be considered a “multimodal” corridor – one that accommodates travel between point A and point B by either truck or rail. For several years, the concept of upgrading this rail infrastructure, and the rail services offered over this infrastructure, has been discussed as one way to reduce the number of through trucks that would otherwise use I-81. The opportunity is generally referred to as “truck to rail diversion.”

The key challenges in advancing this concept are:

- Determining, to the extent practical, the size and nature of the diversion opportunity, the public and private cost of achieving it, and the public benefits resulting from public expenditures;
- Structuring an appropriate relationship between public and private sector interests; and
- Coordinating activities by and within the Commonwealth, with activities by and within other states originating and terminating the diverted traffic.

■ 1.3 Prior I-81 Studies

Opportunities to divert I-81 truck traffic to rail have been addressed in several previous studies and documents, including:

- *Desirability and Feasibility of Establishing Additional Intermodal Transfer Facilities* (2001, under House Joint Resolution 704)
- *The Potential for Shifting Virginia's Highway Traffic to Railroad* (2001, under Senate Joint Resolution 55)
- *The Northeast-Southeast-Midwest Corridor Marketing Study* (2003)
- *The I-81 Corridor Improvement Study*, including the Tier I EIS, Tier I EIS Record of Decision, and supporting studies of truck-rail diversion and toll effects (2007).

Four other recent studies and analyses addressing this issue:

1. A market and operational study being performed privately by Norfolk Southern and its consultant, Woodside Associates;
2. The Virginia Department of Rail and Public Transportation's review process for evaluation of Rail Enhancement Fund applications;
3. Studies performed in support of Norfolk Southern's application for Federal "TIGER" grant funds;
4. The *Virginia Statewide Multimodal Freight Study*, being led by the Commonwealth of Virginia, under which this report was prepared.

■ 1.4 About this Report

Objectives

The primary objective of this report is to comply with the requirements of Virginia's 2007 Appropriations Act, Item 442.

Figure 1. Study Objective

Virginia's 2007 Appropriations Act, Item 442, calls for:

"development of a feasibility plan to define the conditions that would be necessary to divert the maximum amount feasible of the long-haul, through-truck freight traffic to intermodal rail in the Interstate Route 81 Corridor."

Scope of Work

This report represents a coordinated effort of the Multimodal Transportation Planning Office and its consultant team led by CS, and Norfolk Southern Corporation (NS) and its consultant (Woodside Associates), with the participation of Commonwealth VTRANS partners, including the Virginia Department of Transportation and the Virginia Department of Rail and Public Transportation. CS developed independent findings and conclusions based on its own analysis, and performed analysis and validation review of certain study inputs provided by NS (railroad market studies, operational modeling, cost estimates, and financial performance data).

Major task areas addressed in this report include:

- Review and summarize prior work efforts to the I-81 truck-rail diversion issue;
- Coordinate with Norfolk Southern to ensure their internal planning addresses Commonwealth concerns;
- Perform independent review and validation of Norfolk Southern planning results;
- Perform selected analyses of public benefits associated with truck-rail diversion; and
- Identify uncertainties, questions, and/or unresolved issues that could potentially be addressed by further investigation.

Organization

To address the requirements Virginia's 2007 Appropriations Act, Item 442, this report addresses the following topics:

- Definition of current and future freight activity on I-81;
- Potential strategies to achieve the maximum feasible truck to rail diversion, and their respective benefits, costs, and overall feasibility; and
- Action plan to achieve the maximum feasible truck to rail diversion.

2.0 Current and Future Freight Activity in the I-81 Corridor

■ 2.1 I-81 Location and Route Characteristics

Nationally, I-81 extends 855 miles, from the Canada-New York border to Tennessee. Through Virginia, I-81 runs 325 miles, from the West Virginia state line to the Tennessee state line. It runs through or near Bristol, Blacksburg, Roanoke, Lexington, Staunton, Harrisonburg, Front Royal, Winchester, and other important communities; it is the principal vehicular travel corridor through Virginia's Shenandoah Valley. It takes approximately five hours to drive I-81 end-to-end under free-flow conditions.

Figure 2. I-81 and the Interstate Highway System

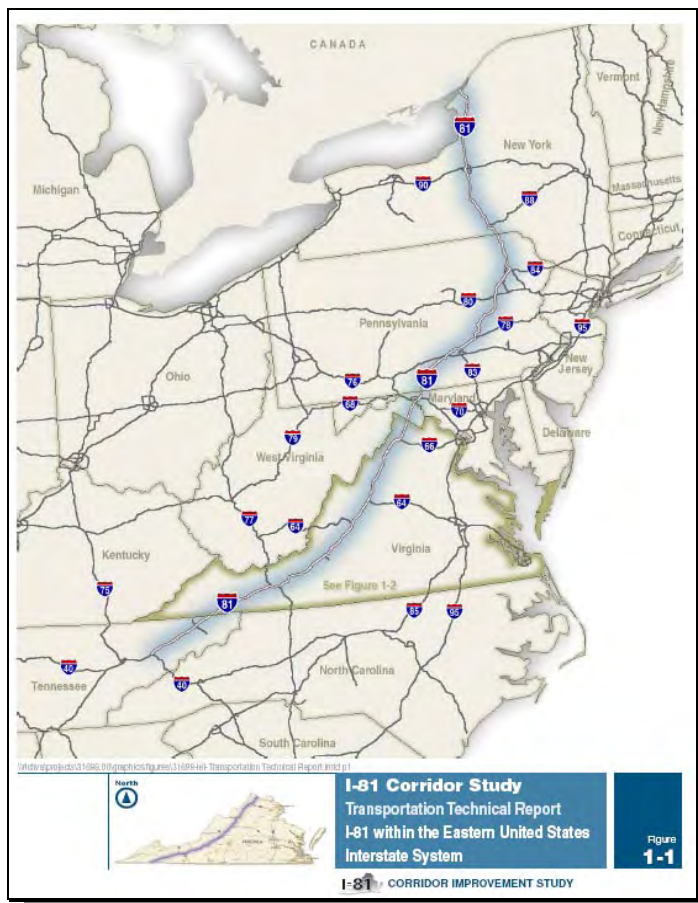
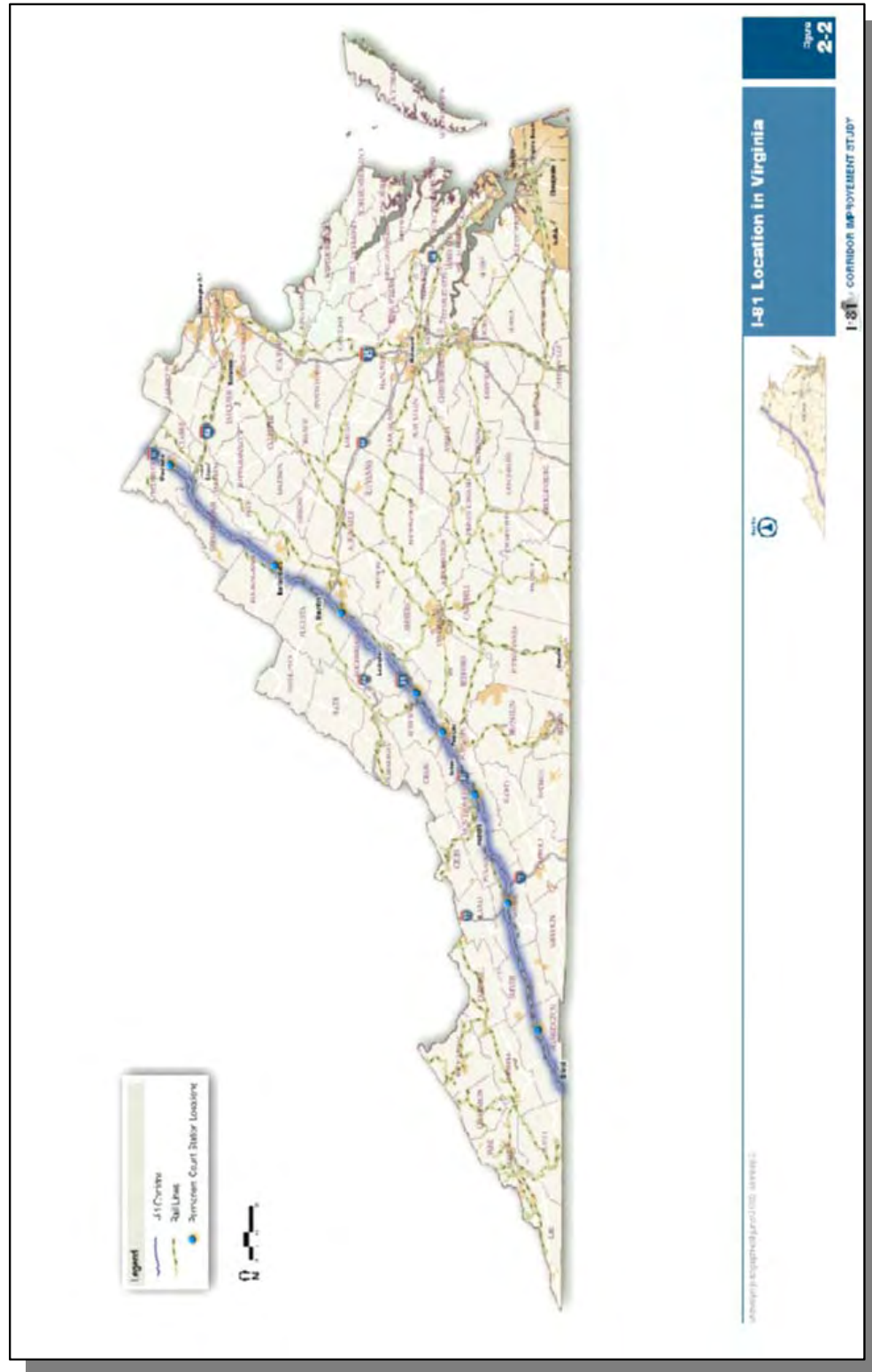


Figure 3. Interstate 81 in Virginia



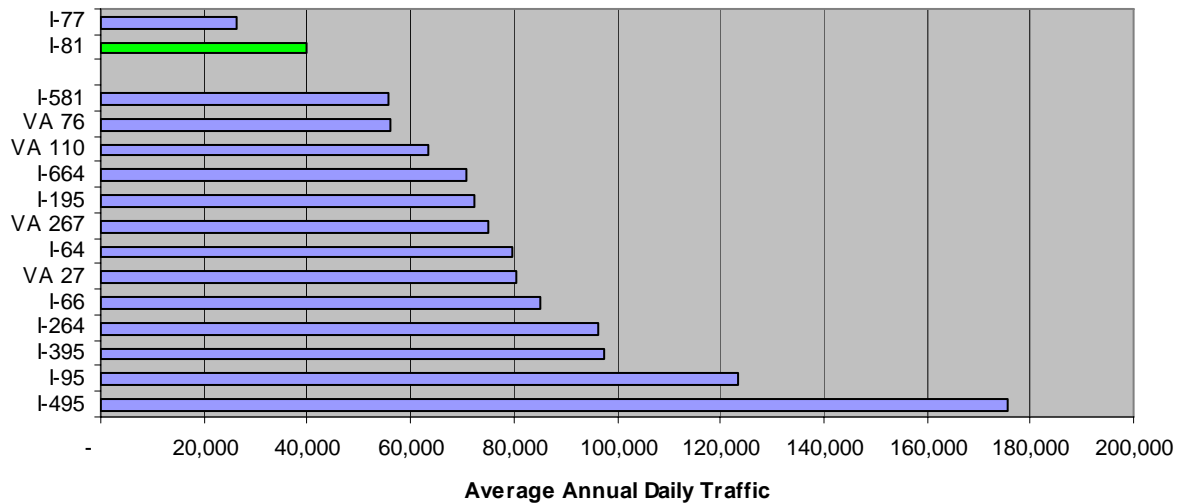
I-81 was completed in 1971, with an original design of two travel lanes in each direction. Over the years, a few sections have been widened (Bristol, Wytheville, Christianburg) and climbing lanes have been added in some locations.

■ 2.2 Vehicle Activity on I-81

Vehicle Counts

Virginia maintains a statewide vehicle count program on its major highways, including collection and/or estimation of truck counts and percentages. Figure 4 following shows the average Virginia AADT (Average Annual Daily Traffic) for all vehicle types, averaged over all highway count segments, for year 2008. Segment counts taken in a single direction on divided highways have been added together, and the volumes in Figure 4 represent bidirectional activity.

Figure 4. Average Annual Daily Traffic (AADT), All Vehicle Types, Averaged Over All Highway Segments, 2008



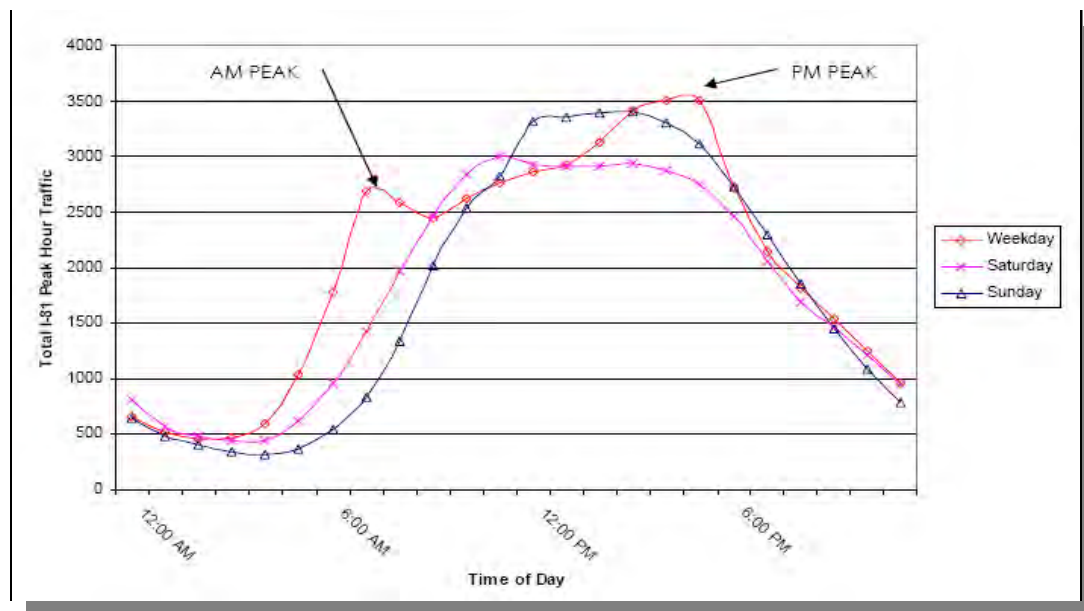
Source: Analysis of Virginia 2008 count data.

The highest average segment count volumes are found on I-495, the Washington, D.C. Beltway, where all segments are in a highly congested urban area. I-95, which traverses both urban and non-urban areas, ranks second with an average of over 120,000 vehicles per segment. I-81, which primarily traverses non-urban areas and carries less local commuter traffic than roads such as I-495 and I-95, ranks 24th among all Virginia roads on AADT, with an average of 39,730 vehicles per day.

The *I-81 Corridor Improvement Study* found that I-81 exhibits significant variations based on time of day, day of week, and month of year.

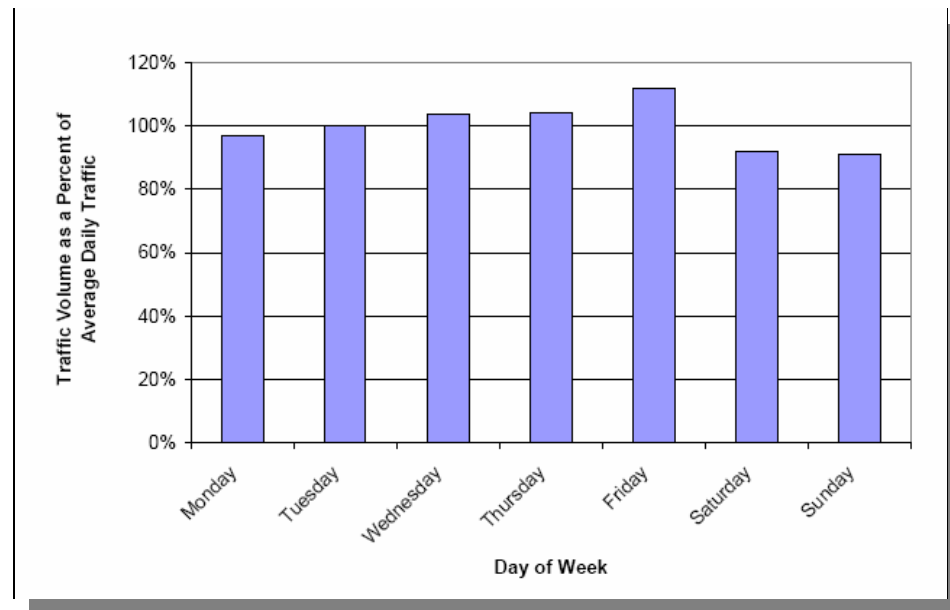
- Over a 24-hour period, volumes range from a low of 500 per hour to a high of 3,500 per hour. Peaking characteristics for total traffic, as reported in the I-81 Corridor Improvement Study, are shown in Figure 5 following.
- Day-of-week variations are shown in Figure 6 following. The lowest days (Saturday and Sunday) are about 90 percent of weekly average volumes; the highest day (Friday) is about 110 percent of average volumes.
- Month of year variations are shown in Figure 7 following. The lowest months (January and February) are around 80 percent of yearly average volumes; the highest months (July and August) are around 110 percent of average volumes.

Figure 5. Average Hourly Variations in I-81 Corridor Traffic 2003



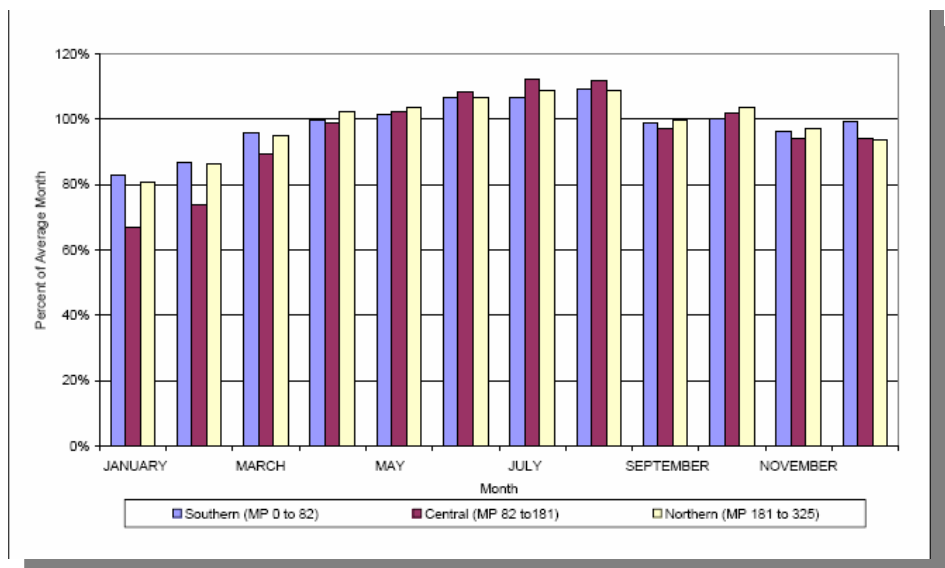
Source: *I-81 Corridor Improvement Study*.

Figure 6. Average Day-of-Week Variations in I-81 Corridor Traffic 2003



Source: I-81 Corridor Improvement Study.

Figure 7. Average Monthly Variations in I-81 Corridor Traffic 2003

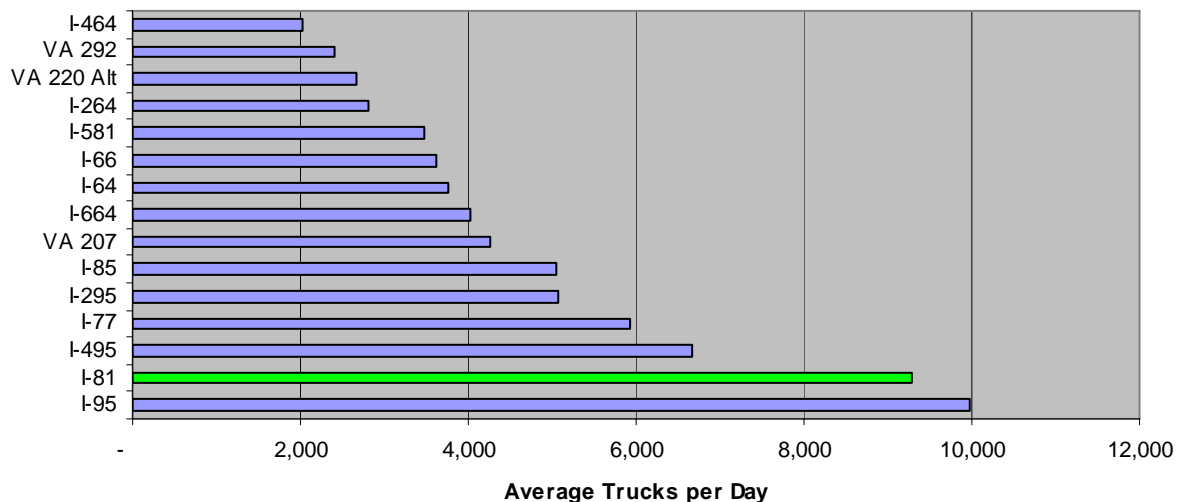


Source: I-81 Corridor Improvement Study.

Truck Counts and Percentages

In 2008, I-81 carried an average of 9,284 trucks per day in both directions, averaged over its entire length. This includes all truck types; almost all trucks on I-81 are Class 5 and higher. According to the Federal Highway Administration's classification system, a Class 5 vehicle is a two-axle, six-tire, "single-unit" vehicle (meaning that the cab and the truck body are not separable). Higher classes mean more axles, and Classes 8 through 13 are tractor-trailer trucks (where the cab and the truck body are separate units).

Figure 8. Average Annual Daily Truck Traffic (AADTT), Averaged Over All Highway Segments 2008



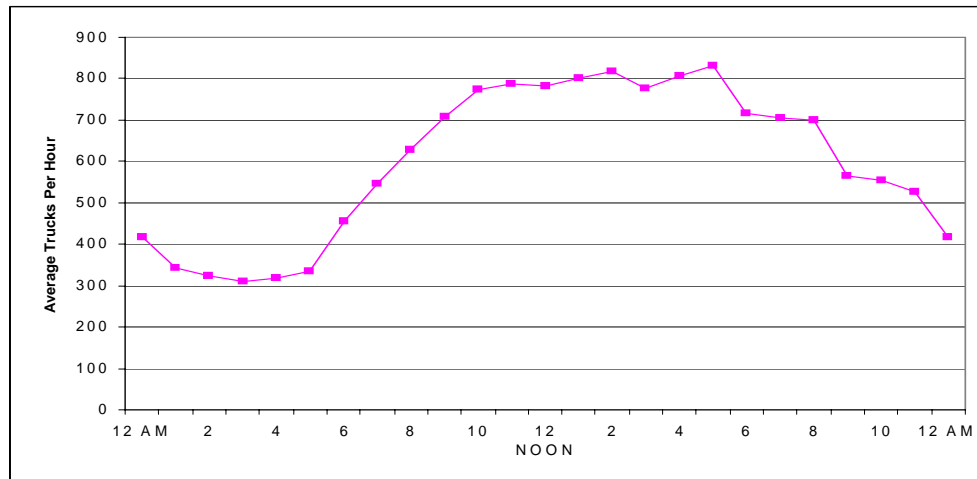
Source: Analysis of Virginia 2008 count data.

On the basis of averaged count segments, I-95 actually carries more trucks than I-81; I-81 ranks a close second. After I-81, there are a number of important truck routes – I-495, I-77, I-295, and I-85 – with more than 5,000 trucks per day.

There are significant variations in truck counts among different segments of any given highway. For I-81, the lowest truck count segment was around 6,000 per day, while the highest was around 15,000 per day. There also are significant variations in truck counts depending on the time of day. Total weekday traffic on I-81 ranges from a low of 500 vehicles per hour (after midnight) to a high of 3,500 vehicles per hour (evening peak).

Analysis of a full day in 2007¹ shows a low of 300 trucks per hour (after midnight) to a high of 800 trucks per hour (constant from 10:00 a.m. to 5:00 p.m.).

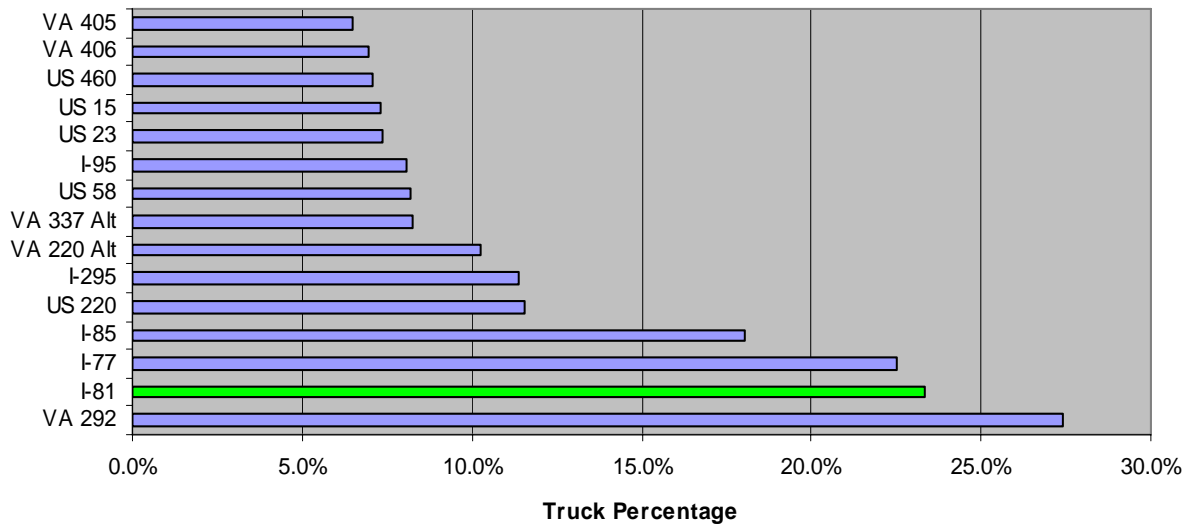
Figure 9. Average Hourly Truck Traffic at Three I-81 Locations
July 19, 2007; Tennessee State Line, West Virginia State Line, and Roanoke



In 2008, trucks represented an average of 23.4 percent of all vehicle types on I-81. The only road with a higher percentage was VA 292, a short connector between I-81 and U.S. 11. Very high truck percentages also were seen on I-77 and I-85, both of which are major truck routes with lower volumes of passenger traffic. The truck percentage on I-95 is just 8 percent, because it carries more cars than other major truck routes. The truck percentage on I-495 is even lower, at less than 4 percent. See Figure 10 following.

¹ This was the day on which 24-hour truck surveys were conducted at I-81 weigh stations.

Figure 10. Truck Percentages Averaged Over All Highway Segments, 2008
Rankings Among Routes Over 1,000 AADDT



Source: Analysis of Virginia 2008 count data.

Types of Truck Moves

Every truck movement on I-81 falls into one of three categories:

1. Through truck movements, which begin and end in states other than Virginia.
2. Inbound and outbound truck movements. These are truck trips that begin in another state and end in Virginia, or begin in Virginia and end in another state.
3. Internal truck movements, which begin and end in Virginia.

Technical work for the *I-81 Corridor Improvement Study* suggested that 58.2 percent of trucks on I-81 were passing through Virginia. Virginia's TRANSEARCH² dataset also suggests the largest share of I-81 truck traffic is associated with through truck movements. The data mapped on Figure 11 suggests that I-81 is Virginia's leading through-truck route (followed by I-95 and I-77). Figure 12 suggests that I-81 handles less Virginia-oriented traffic (inbound, outbound, or internal flows) than through trucks.

² TRANSEARCH is a commercial data product of Global Insight, Inc. It provides estimates of freight movement (tons and units) between North American origin and destination regions, by commodity class and transportation mode. It includes both public-source and proprietary data.

Figure 11. Estimated Through Truck Tonnage
TRANSEARCH 2004 Data

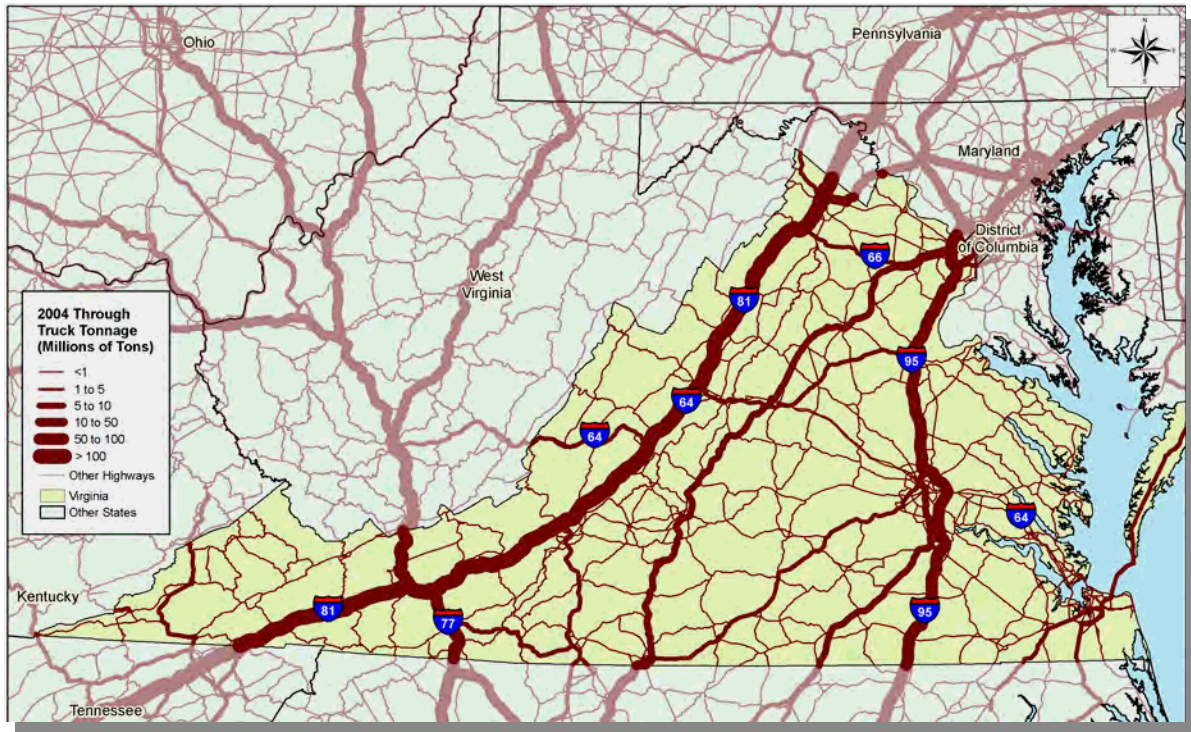
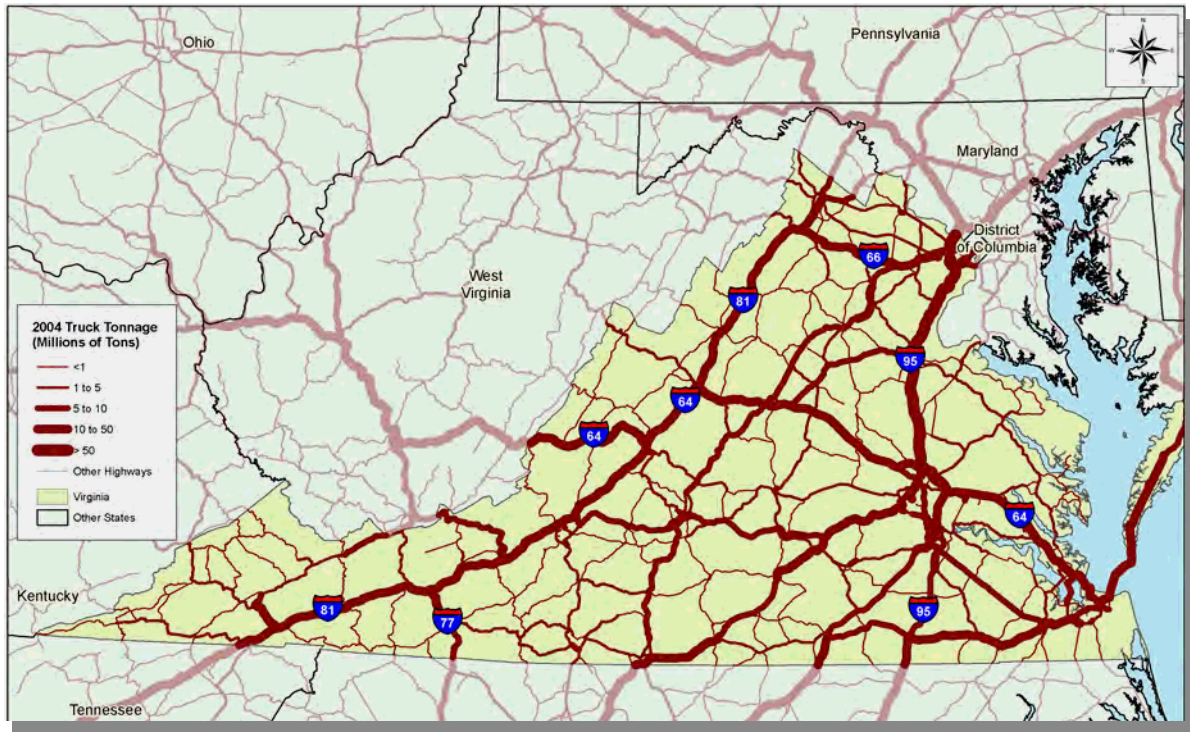


Figure 12. Estimated Non-Through Truck Tonnage
TRANSEARCH 2004 Data



Origin-Destination Surveys

To supplement existing information, the Commonwealth recently conducted an extensive truck survey effort. Truckers passing through I-81 weigh stations at Troutville (between the I-81/I-77 and the I-81/I-64 interchanges, near Roanoke) and Stephens City (north of the I-81/I-66 interchange, near Winchester) were randomly selected for brief interviews. Both locations show higher truck traffic than the corridor average for I-81.

Information was collected over the same 24-hour weekday period (Thursday, July 19, 2007) at both locations. In total, approximately 3,000 usable responses were obtained, which is roughly 10 percent of the total truck traffic during this period.³ Surveys revealed that around 62 percent of trucks were passing through Virginia, 32 percent were moving freight between Virginia and other states, and 6 percent were passing entirely within Virginia, as summarized in Table 1 following.

³ This is considered a very good sample rate. Trucker willingness to participate was excellent, with very few refusals. Interviews averaged 3 minutes in length. The limiting factor was the amount of parking available at each weigh station – trucks had to be pulled into the parking area, interviewed, and then sent back through the weigh station traffic stream.

Figure 13. Location of Virginia I-81 Weigh Station Truck Surveys**Table 1. 24-Hour Origin-Destination Surveys at I-81 Weigh Stations**

	Troutville NB	Stephens City NB	Troutville SB	Stephens City SB	Bidirectional Average
Total Trucks Counted	7,779	8,667	6,970	7,960	15,688
Through Trucks	5,467	5,259	4,117	4,578	9,711
Inbound/Outbound Trucks	1,929	2,998	2,154	3,037	5,059
Internal Trucks	384	410	699	345	919
Through Percent	70.3%	60.7%	59.1%	57.5%	61.9%
Inbound/Outbound Percent	24.8%	34.6%	30.9%	38.2%	32.2%
Internal Percent	4.9%	4.7%	10.0%	4.3%	5.9%

Source: Analysis of I-81 Weigh Station truck survey responses, July 19, 2007.

Figures 14 and 15 following show the leading state origin-state destination pairs for trucks using I-81. Also, the I-81 weigh station surveys were part of a larger statewide survey program, and it is interesting to compare the I-81 results with other Virginia interstates. As shown in Figure 18, I-77 actually had the highest percentage of through trucks, followed by I-81 and I-85. I-95 also shows a substantial percentage of through truck traffic.

Figure 14. Leading Origin-Destination Pairs for I-81 Trucks
Stephens City

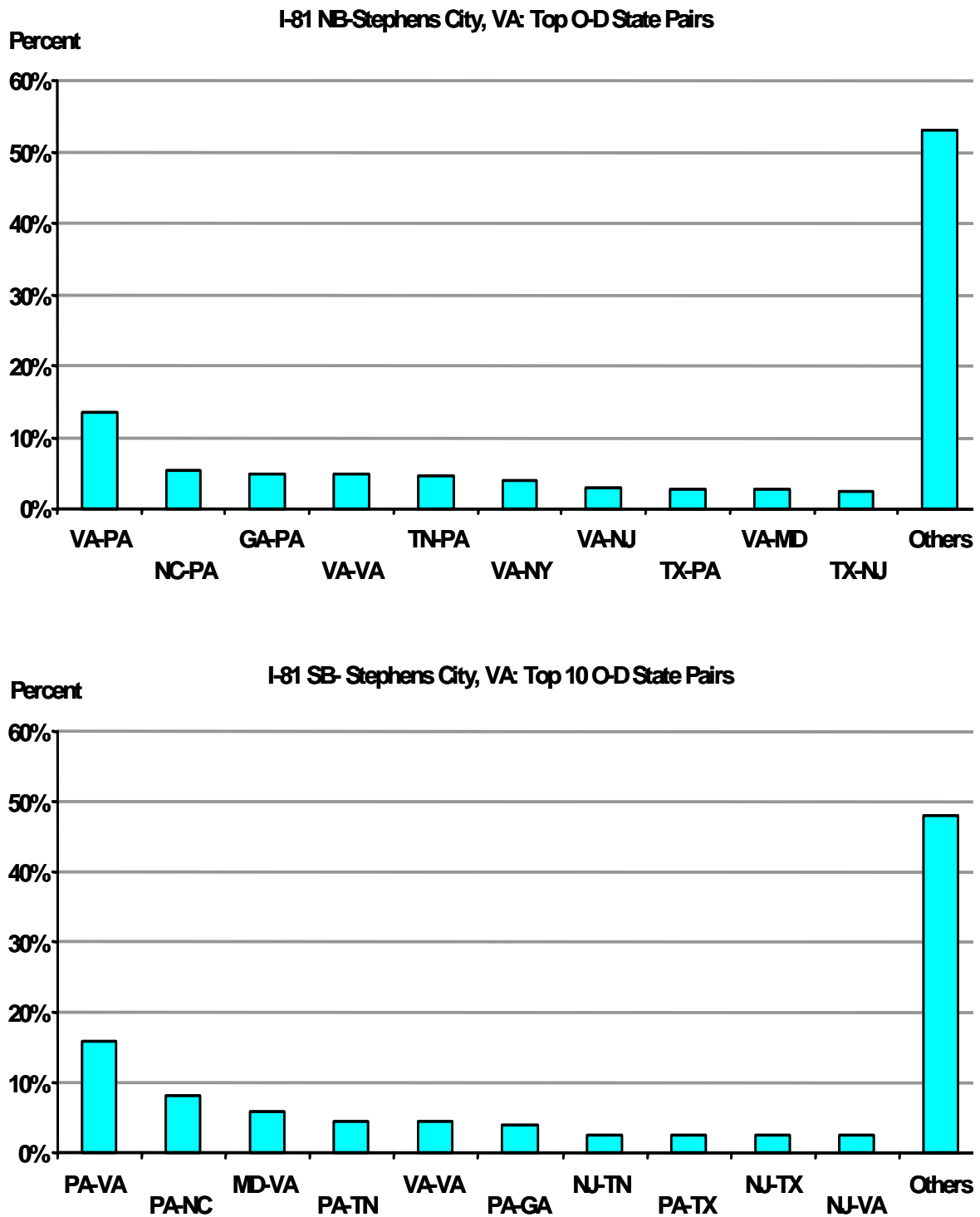


Figure 15. Leading Origin-Destination Pairs for I-81 Trucks
Troutville

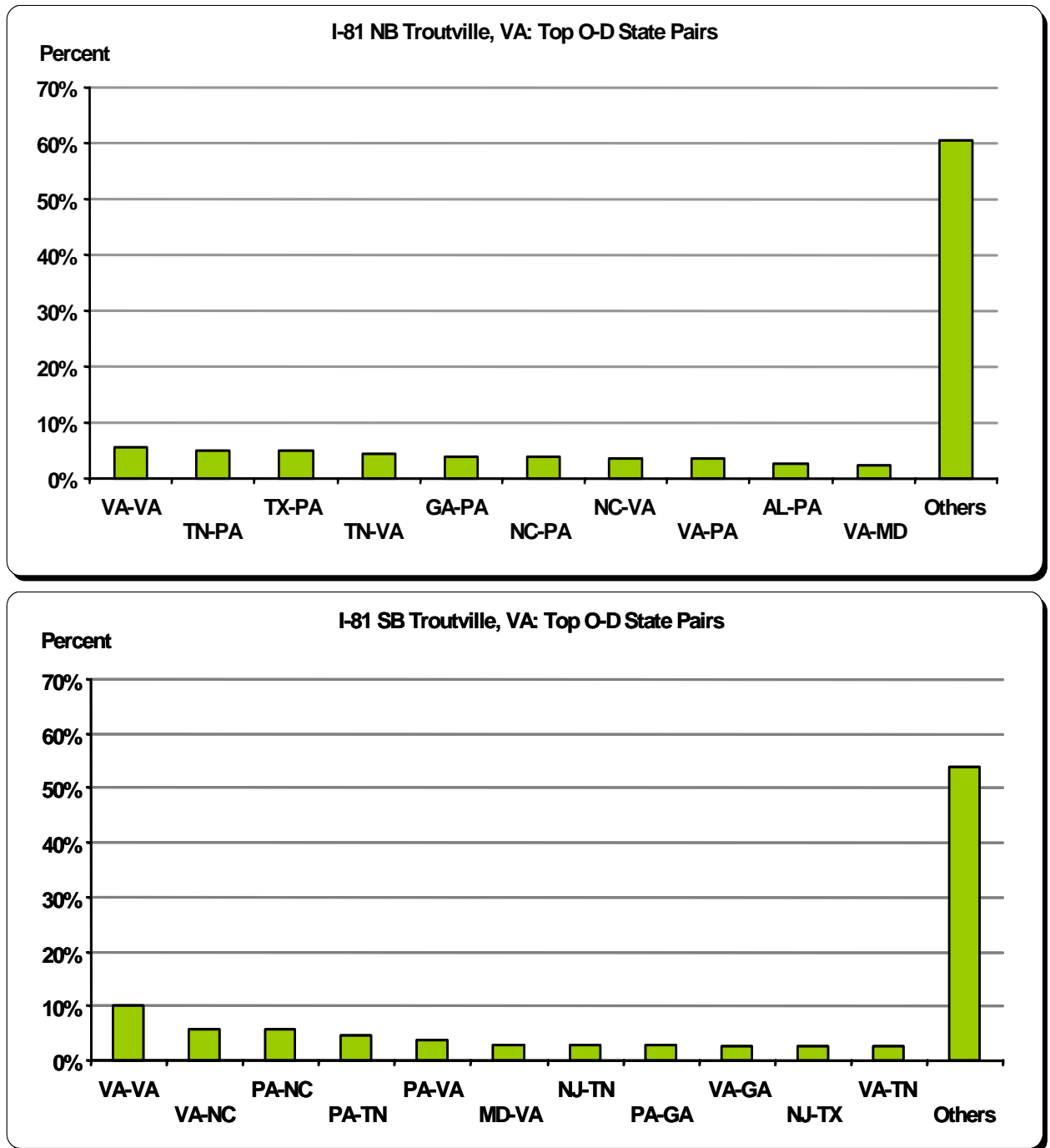
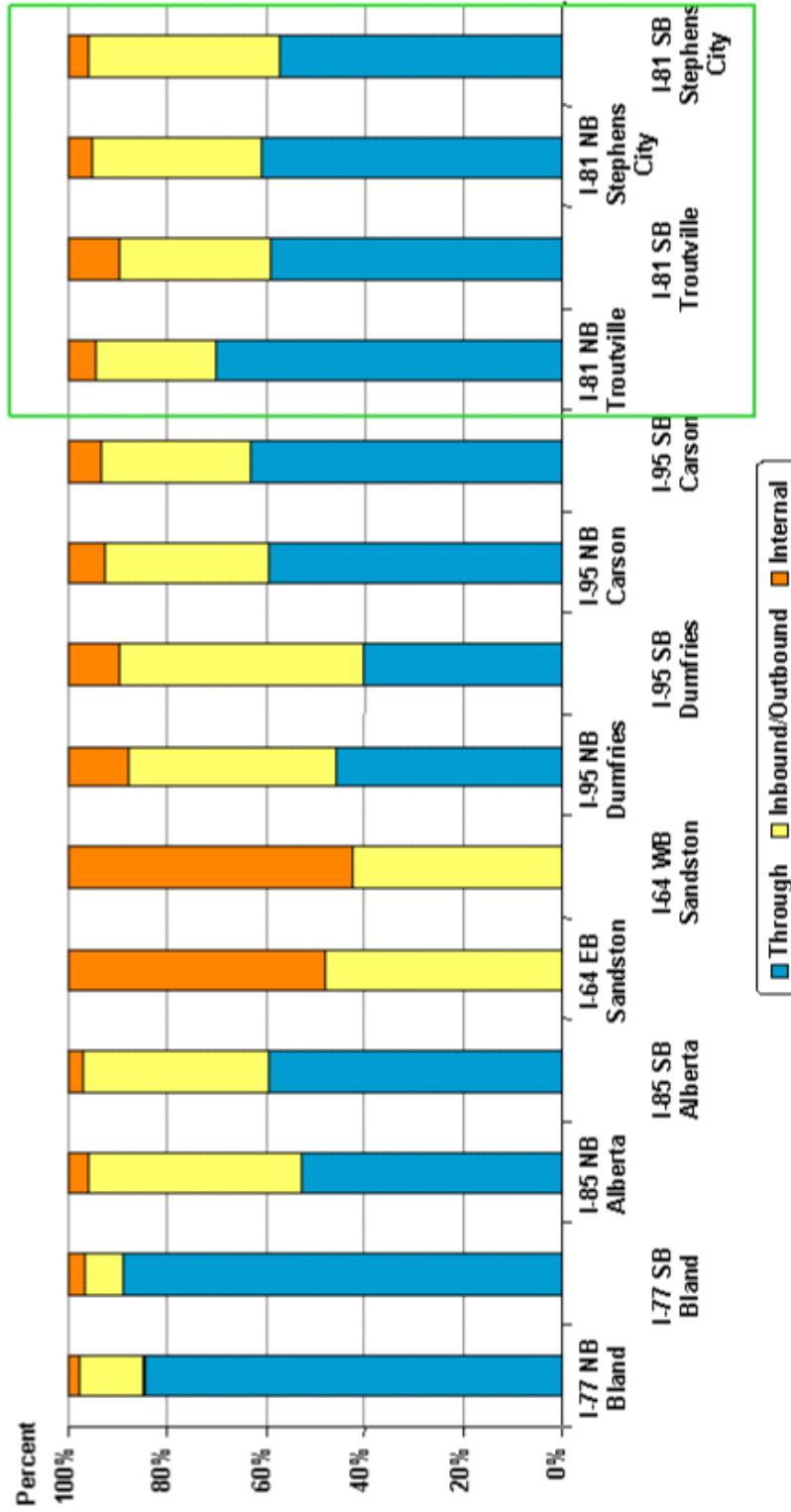


Figure 16. Percentages of Through, Inbound/Outbound, and Internal Truck Trips on Virginia Interstates



■ 2.3 Current and Future Performance of I-81

Findings of the I-81 Corridor Improvement Study

The *I-81 Corridor Improvement Study Tier I EIS* identified the following performance deficiencies under current conditions:

- In the northbound direction, 24 miles (7 percent) of I-81 operates worse than the level of service standard.
- In the southbound direction, 32 miles (10 percent) of I-81 operates worse than the level of service standard.
- The most constrained segment of I-81 appears to be in the Roanoke area between Exits 141 and 143 in the northbound direction and between Exits 140 and 143 in the southbound direction.
- Approximately 70 percent of the existing exists have geometric deficiencies.
- More than two-thirds of I-81 in Virginia has inside shoulder widths that do not meet AASHTO geometric design criteria, based on the volume of heavy vehicles using the corridor.
- More than 100 locations have sight distances that do not meet AASHTO geometric design criteria because of the alignment of the highway.
- Ten locations have conditions that may slow truck traffic to speeds below the minimum for interstate travel.
- Approximately 53 bridges (42 percent) have vertical clearances less than AASHTO geometric design criterion of 17 feet 6 inches.

Figure 17 following illustrates the level of service on I-81 under existing conditions. Figure 18 following shows the projected level of service under future “no-build” conditions, with much of I-81 reaching level of service D, E, or F.

Figure 17. Existing Conditions I-81 Level of Service Estimate

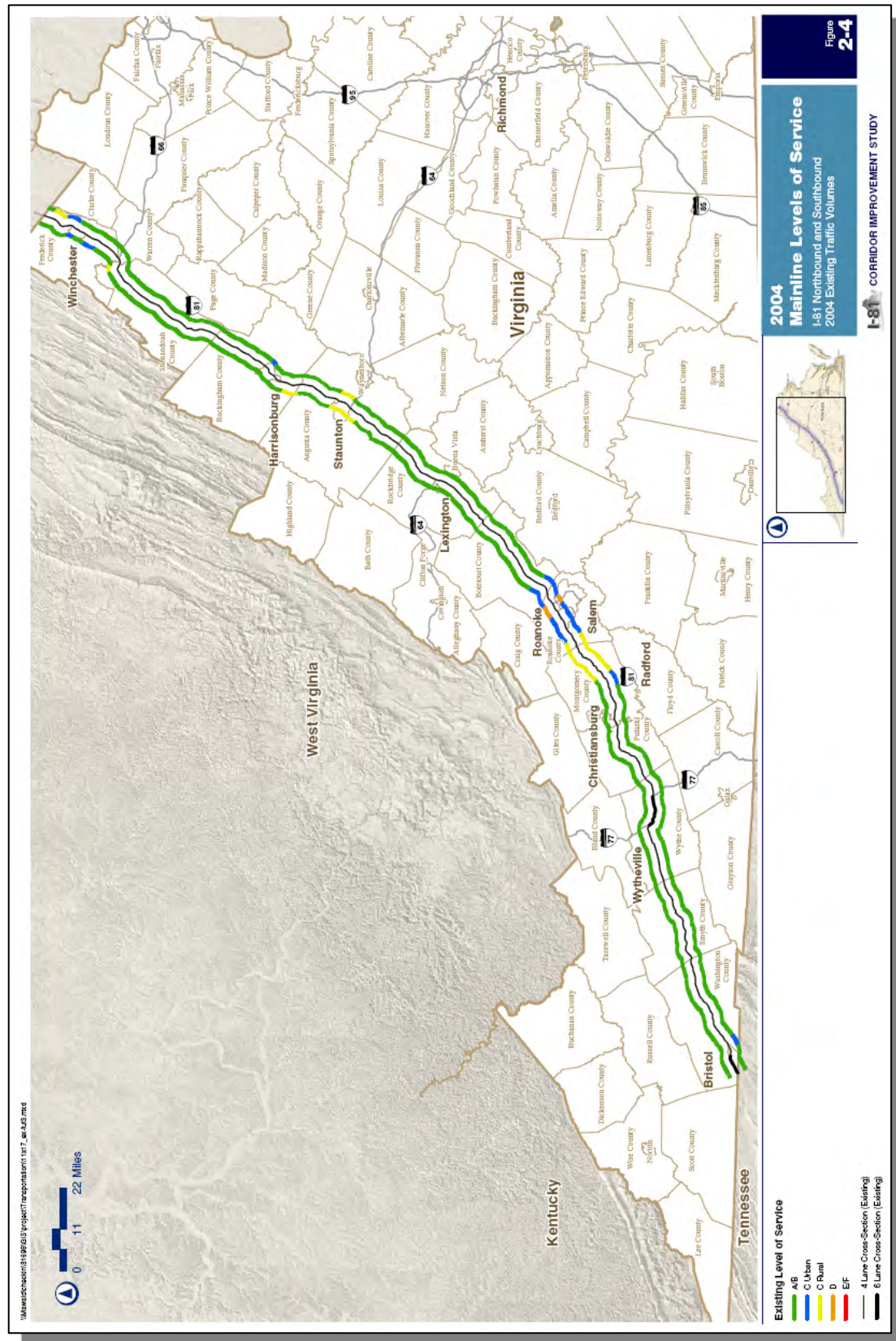
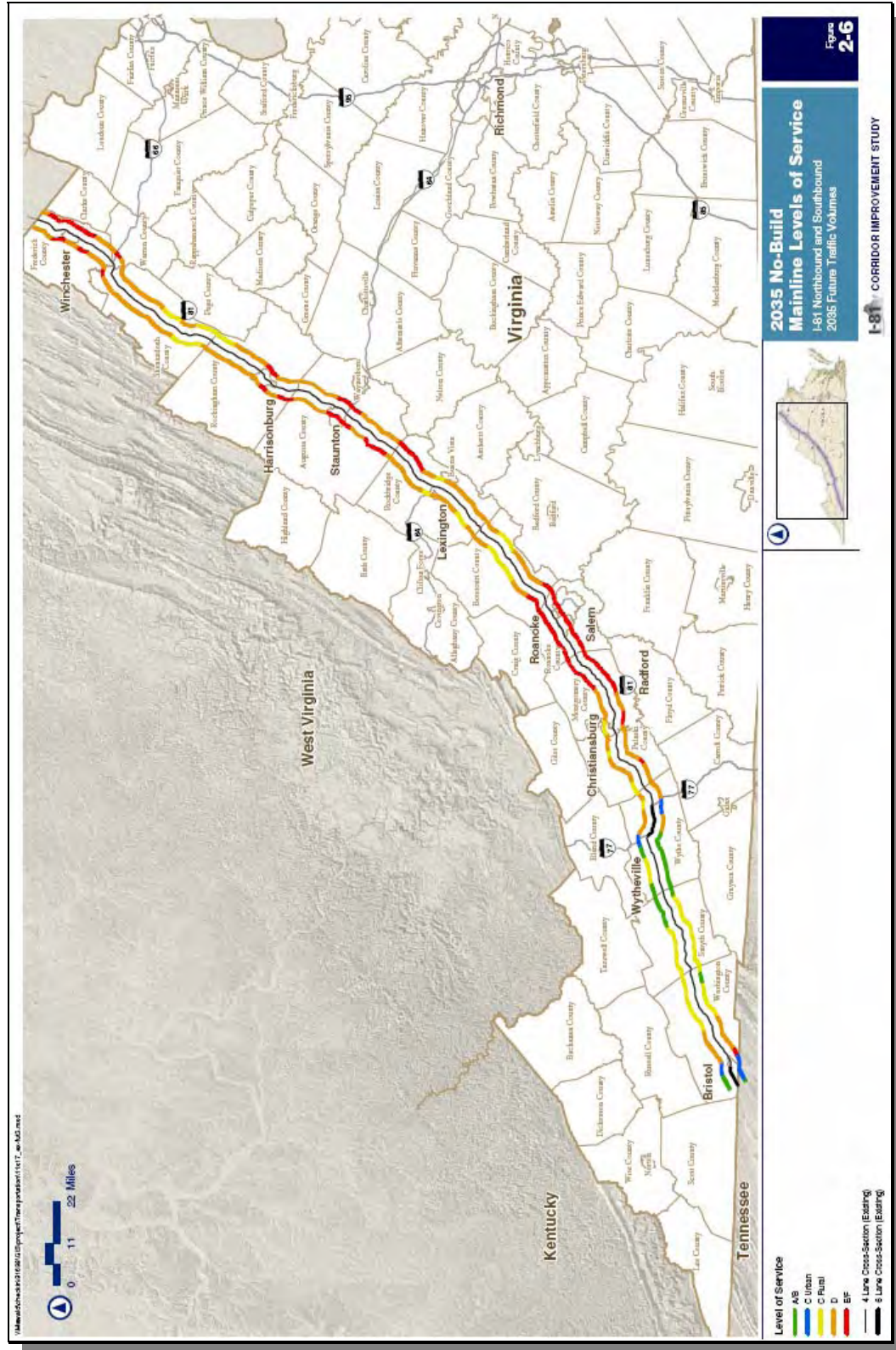


Figure 18. Future (2035) “No-Build” I-81 Level of Service Estimate



Growth Forecasts in the I-81 Corridor Improvement Study

The level of service projections in the I-81 Corridor Improvement Study Tier I EIS are based on a set of growth forecasts suggesting total vehicle traffic will grow at a rate of 1.7 percent to 2.1 percent annually. The actual growth rates used in the EIS vary by segment within this range, and assume that heavy trucks will grow at 2.8 percent annually.

This truck forecast was consistent with other sources available at the time. The Federal Highway Administration's Freight Analysis Framework-2 (2002) suggested that truck tonnage shipped to and from Virginia would increase from around 150 million tons in 2002 to around 349 million tons in 2035, corresponding to an average annual growth rate of 2.6 percent. The *Virginia Statewide Multimodal Freight Study, Phase I* anticipated that Virginia truck volumes over the entire system would increase by 115 percent between 2004 and 2035, corresponding to an average annual growth rate of 2.5 percent, based on year 2004 TRANSEARCH data. A more detailed "select link" analysis of the TRANSEARCH data suggested that through truck volumes on I-81 would increase by 139 percent between 2004 and 2035, corresponding to an average annual growth rate of 2.8 percent.

More recently, the U.S. economy has experienced two important events: a temporary spike in fuel prices, followed by a significant and prolonged recession. The effects of these events on I-81 truck forecasts are discussed below.

Fuel Price Sensitivity

The relationship between changes in transportation demand and changes in cost can be summarized as an "elasticity." For example, an elasticity of -0.50 means that a 1 percent increase in price corresponds to a 0.5 percent decrease in demand; an elasticity of -2.00 means that a 1 percent increase in price corresponds to a 2 percent decrease in demand.

Unfortunately, the literature on freight elasticities does not tell a clear story. One recent study⁴ cited compiled results from prior studies. The widest range cited suggests that price elasticities for trucking range from -0.04 to -2.97 and price elasticities for rail range from -0.08 to -2.68, depending on commodity. The narrowest range cited suggests that elasticities for both trucking and rail range from -0.25 to -0.35. The average value of -0.30 is suggested for the present analysis, mostly because it yields the most plausible results.⁵

⁴ "Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior." Todd Littman, Victoria (BC) Transport Policy Institute, March 31, 2008. Mr. Littman presents trucking elasticities in a table sourced from Small and Winston, Victoria Transport Policy Institute (1999).

⁵ Oum (1979) cites "cross elasticities" for rail-truck and truck-rail shifts in Canada between 1950 and 1974, but the ranges are quite large and the applicability of this data to current U.S. conditions is unknown.

Fuel costs per ton-mile vary depending on regional price differences and the terrain through which freight is traveling. Travel through terrain with elevation changes consumes more fuel, and in the case of rail may require more motive power. On average, according to the Texas Transportation Institute, rail provides 413 ton-miles of freight transport per gallon, versus 155 ton-miles per gallon for truck.⁶ This is a composite figure reflecting different types of movements, commodities, and equipment types.

Using the average price elasticities and the TTI fuel efficiency factors, one can construct a simplified model showing the relationship of fuel price and demand by mode. The overall finding is that fuel price increases affect trucking demand more strongly than rail demand, but the effect is to reduce demand for both modes. For the hypothetical case of a 20-ton shipment moving 1,000 miles, if the at-the-pump diesel fuel increases from \$3 to \$6 per gallon, it would result in 10.5 percent increase in cost by rail and an 18.5 percent increase in cost by truck; this would in turn result in a 3.1 percent decline in traffic by rail and a 5.9 percent decline in traffic by truck. If at-the-pump fuel price increases from \$3 to \$9 per gallon, it would result in 20.9 percent increase in cost by rail and a 37.1 percent increase in cost by truck; this would in turn result in a 6.3 percent decline in traffic by rail and an 11.1 percent decline in traffic by truck.

Table 2. Example of Fuel Cost Effects on Truck and Rail Demand

	Rail	Truck
Shipment Distance (miles)	1000	1000
Shipment Weight (tons)	20	20
Cost per Unit Mile	\$ 1,388	\$ 2,088
Shipment Cost (dollars)	\$ 1,388	\$ 2,088
Ton Miles	20,000	20,000
Fuel Consumption Rate (ton-miles/gallon)	413	155
Fuel Consumption (gallons)	48.4	129.0
Current Average Fuel Cost Assumed	\$ 2.50	\$ 3.00
Shipment Cost, Non-Fuel Related	\$ 1,267	\$ 1,701
Fuel Cost at \$3.00 Pump Price / \$2.50 Railroad Price	\$ 121	\$ 387
Fuel Cost at \$6.00 Pump Price / \$5.50 Railroad Price	\$ 266	\$ 774
Fuel Cost at \$9.00 Pump Price / \$8.50 Railroad Price	\$ 412	\$ 1,161
Shipment Cost at \$6.00 Pump Price / \$5.50 Railroad Price	\$ 1,533	\$ 2,475
Shipment Cost at \$9.00 Pump Price / \$8.50 Railroad Price	\$ 1,679	\$ 2,862
% Increase in Cost at \$6.00 Pump Price / \$5.50 Railroad Price	10.5%	18.5%
% Increase in Cost at \$9.00 Pump Price / \$8.50 Railroad Price	20.9%	37.1%
Average Elasticity	-0.30	-0.30
% Decline in Demand at \$6.00 Pump Price / \$5.50 Railroad Price	-3.1%	-5.6%
% Decline in Demand at \$9.00 Pump Price / \$8.50 Railroad Price	-6.3%	-11.1%

⁶ "A Modal Comparison of Domestic Freight Transportation Effects on the General Public," Texas Transportation Institute, December 2007.

The fact that fuel cost increases are likely to hit trucking proportionally harder than rail could mean that some truck freight shifts to rail, or that trucks are utilized more efficiently (heavier loadings, fewer empty moves), or that truck commodities are moved shorter distances, or that truck commodities increasingly utilize alternative modes such as rail or barge. With increasing fuel costs, rail also is likely to shed tonnage and/or ton-mileage (as some customers reduce shipping volumes and/or shipping distances) – but its losses should be more than offset by the traffic it picks up from trucking. For now, fuel prices are at reasonable and historic levels. However, we feel it is only a matter of time before prices reach these higher levels, whether through slow and gradual growth or sudden jumps. As it does, the reasoning above will apply.

Fluctuations in the U.S. Economy

Leading up to this report, there were signs of an emerging recession – a shrinking job market, reduced consumer spending and confidence, increasing losses from bad loans, plunging value of the dollar, the first insurance company bailouts, etc. At the same time, there were huge spikes in the costs of fuel and building materials. More recently and dramatically, the downturn spread across a broad spectrum of the economy, affecting banking, housing, the auto industry, and related sectors. Unemployment has risen to levels not seen in decades, credit is tightening, and buying power is shrinking. Both production and consumption – the critical drivers of freight movement – have slowed significantly. The result is that freight movement across all modes – truck, rail, water, and air – has flattened out, or even dropped, compared to previous levels.

Changes in I-81 Traffic Volumes

Based on available data, it appears that the combined effects of fuel price spikes and recession have led to reduced travel on I-81. Around half the drop is attributable to reductions in trucks, and half to other vehicle types.

Table 3. Comparison of Annual Traffic Estimates for I-81

	Total Traffic	Truck Traffic
2003 Annual Average (from <i>I-81 Corridor EIS</i>)	46,400	~ 12,000
2005 Annual Average (from Commonwealth Traffic Count analysis in the <i>Virginia Statewide Freight Plan Phase I</i>)	44,185	11,805
2008 Annual Average (from analysis of most current available Commonwealth Traffic Counts) ⁷	39,730	9,284

⁷ See http://www.virginiadot.org/info/2008_traffic_data.asp.

Implications for I-81 Truck Forecasts

Forecasts that until recently seemed conservative and reasonable now seem far too optimistic. In response, freight planners are adjusting their forecasts in three ways:

1. Some freight planners are completely reworking their long-term forecasts to reflect lower long-term growth rates.
2. Some have adopted a strategy that assumes the U.S. economy will rebound and resume performing at historic levels, but not before a five-year period representing the recessionary downturn followed by recovery to historic levels. Planners using this approach are keeping their existing forecasts – but “sliding them forward” by five years, to reflect the impacts of the recession. In other words, they are using the same forecast graphs, but changing the years to which the numbers apply.
3. Some have adopted a strategy that assumes the U.S. economy has stabilized at a low point, and will resume historic growth from this point forward. They are keeping their prior forecast growth rates, but applying them to lower “base” years reflecting recessionary conditions.

This report adopts the third strategy, applying the 2.8 percent growth rate to actual year 2008 truck volumes for I-81, which reflect freight operations during the recessionary period. This represents our **base forecast**.

Table 4 following shows how this growth rate is applied to the average bidirectional segment count volumes for the I-81 Corridor in year 2008 to generate forecasts of truck traffic in the absence of truck to rail diversion. This forecast is intended only to help “size the market” for truck to rail diversion. It does not represent an official Commonwealth of Virginia forecast, and is not intended or designed for application or use outside of this Report.

Table 4. Updated I-81 Truck Forecasts, No Truck-Rail Diversion

Base Forecast (2.8 Percent)		
	Trucks per Day	Trucks per Year
2008	9,284	3,388,660
2009	9,544	3,483,542
2010	9,811	3,581,082
2011	10,086	3,681,352
2012	10,368	3,784,430
2013	10,659	3,890,394
2014	10,957	3,999,325
2015	11,264	4,111,306
2016	11,579	4,226,423
2017	11,903	4,344,762
2018	12,237	4,466,416
2019	12,579	4,591,475
2020	12,932	4,720,037
2021	13,294	4,852,198
2022	13,666	4,988,059
2023	14,049	5,127,725
2024	14,442	5,271,301
2025	14,846	5,418,898
2026	15,262	5,570,627
2027	15,689	5,726,604
2028	16,129	5,886,949
2029	16,580	6,051,784
2030	17,044	6,221,234
2031	17,522	6,395,428
2032	18,012	6,574,500
2033	18,517	6,758,586
2034	19,035	6,947,827
2035	19,568	7,142,366

■ 2.4 Rail Lines Paralleling I-81

There are two primary rail routes paralleling I-81 – the Piedmont Line and the Shenandoah Line. Both are owned and operated by the Norfolk Southern Rail Road (NS). Within Virginia, the Shenandoah Line runs northeast from the Tennessee state line to the West Virginia state line; the Piedmont Line runs northeast from the North Carolina state line, reaches Manassas, and then heads west to join the Shenandoah Line at Riverton Junction near Front Royal. Both routes are single-track, with additional tracks in various locations to allow trains moving in opposing directions to pass each other.

The can be transferred between rail and truck via lift equipment. They are usually marked with the name of a trucking company (Fed Ex, Schneider, J.B. Hunt, Old Dominion, etc.) or a retailer (WalMart, Giant, McDonalds, etc.).⁸

- **Non-intermodal** rail traffic is what railroads handled prior to the introduction of intermodal services – primarily coal, grain, and other heavy, lower-value commodities. (One exception to the “lower value” rule is automobiles, which can be shipped in specially designed “autoracks.”) Non-intermodal service uses a variety of rail car types: dry bulk hoppers cars, liquid bulk tank cars, flatcars, boxcars of varying lengths, etc. All of these equipment types are unique to the railroad, and cannot be interchanged with other transportation modes. Non-intermodal service can be very competitive over short distances when “unit trains” (trains made up of a single type of railcar, with all cars moving between the same origins and destinations) are employed. Non-intermodal service becomes increasingly challenging when trains handle multiple car types, moving to and from multiple destinations, because of the extra handling involved.

The Piedmont and Shenandoah lines offer travel speeds of up to around 30 mph for intermodal service. In 2006, the lines handled around 500,000 intermodal units (containers and dry vans); this figure is expected to grow to around 1.1 million units by 2035. The number of intermodal trains is expected to grow from 141 per week in 2006 to 203 per week in the year 2020. This represents natural growth, captured in the normal course of business, and does not assume any special efforts to achieve truck to rail diversion. The number of non-intermodal trains is expected to remain constant through 2020. The Piedmont Line also carries passenger trains (128 per week in 2006).

⁸ Other truck types – liquid bulk tankers, dry bulk hoppers, flatbeds, etc. – can be handled on railcars, provided they are rolled on and rolled off the railcar, since these trucks cannot be transferred using conventional lift equipment. A special loading system, known as “open technology,” is required. The I-81 Corridor currently does not provide open technology service. The opportunity to introduce such a service is discussed at length later in this report.

Figure 20. Examples of Intermodal Rail Service



Figure 21. Examples of Non-Intermodal Rail Service



Table 5. I-81 Freight Rail Volumes and Forecasts
No Truck-Rail Diversion

	Shenandoah Line	Piedmont Line
Average Freight Train Service Speeds	Up to 30 mph average	
Intermodal Units, 2006	500,000	
Intermodal Units, 2035	1,100,000	
Intermodal Trains per Week, 2006	60	81
Intermodal Trains per Week, 2020	82	121
Non-Intermodal Trains per Week, 2006	154	338
Non-Intermodal Trains per Week, 2020	153	340
Mileage	352	282

Source: Norfolk Southern.

3.0 Strategies to Achieve the Maximum Feasible Diversion

■ 3.1 Potentially Divertible Trucks

Previously, as shown in Table 4, we estimated the current truck traffic using I-81 (an average of 9,284 trucks per day, or nearly 3.4 million trucks per year in 2008) as well as future forecasted truck traffic through the year 2035. Most of these trucks can be considered potentially divertible, in that it is possible to construct a theoretical service or scenario to shift them from truck to rail. However, there are some limitations on the opportunity, and some types of trucks must be eliminated from further consideration as possible candidates for truck to rail diversion.

Travel Distance Exclusions

Some rail services are competitive with trucking at shorter distances, but these are almost always bulk commodities moving in unit trains. Except for movements of heavy commodities that never need to see a truck – such as coal or clay moving straight from a mine to a power plant or a port – freight that can be moved in less than a single driving day (11 hours, according to current Federal hours-of-service standards) have historically preferred trucking. This usually corresponds generally to a minimum distance of around 500 miles using conventional intermodal rail technology. However, there are rail technologies that are specifically designed to improve the competitiveness of intermodal rail at shorter distances, and these might be deployed in rail services through Virginia. Therefore, it is important to understand the distances that I-81 trucks are traveling. From the I-81 truck surveys, we know trucks are doing one of these things:

- Traveling through Virginia, using only I-81 and no other routes. We estimate that all of these trips are at least 500 miles in length.
- Traveling through Virginia, using I-81 in combination with other routes such as I-77, I-66, I-495/I-95, etc. We estimate that 98.3 percent of these trips are at least 500 miles.
- Traveling into or out of Virginia using I-81 and other routes. We estimate that 21.6 percent of these trips are at least 500 miles in length.
- Traveling entirely within Virginia using I-81 and other routes. We estimate that none of these trips are 500 miles in length.

Table 6. Percent of I-81 Trucks by Trip Length and Type

	Percent of I-81 Trucks	Share Over 500 Miles	Share Under 500 Miles
I-81 only through Virginia	40.5%	100.0%	0.0%
I-81 and Other Routes through Virginia	21.3%	98.3%	1.7%
I-81 to and from Virginia	32.1%	21.6%	78.4%
I-81 entirely within Virginia	6.0%	0.0%	100.0%
Total	100.0%	68.4%	31.6%

Source: CS analysis of Commonwealth truck surveys.

Table 7. Estimated I-81 Trucks (in Year 2008) by Trip Length and Type

	Trucks Per Day	Number Over 500 Miles	Number Under 500 Miles
I-81 only through Virginia	3,764	3,764	-
I-81 and Other Routes through Virginia	1,981	1,947	34
I-81 to and from Virginia	2,981	643	2,339
I-81 entirely within Virginia	557	-	557
Total	9,284	6,354	2,930

Source: CS analysis of Commonwealth truck surveys.

Of the 9,284 trucks per day on I-81 in 2008, around 5,711 would be classified as “long-haul through trucks.” These are the trucks that meet two criteria: they represent trips over 500 miles, and they represent trips passing through Virginia, using I-81 only (3,764 trips) or I-81 and other routes (1,947).

Although the original intent of this report was to focus on the diversion of long-haul through trucks, we also are interested in the potential to divert long-haul truck trips that begin and end in Virginia rather than passing through, as well as the potential to divert trips of less than 500 miles. Therefore, at this stage of the analysis, we would not exclude any of these trucks from further consideration based solely on length of haul.

Geography Exclusions

Both I-81 and the rail lines paralleling I-81 run generally from southwest to northeast, and serve very similar geographies. Looking at the places a trucker goes using I-81, most of those places also can be reached effectively via rail. There are only two exceptions.

- One exception is trucks using I-81 as part of moves that are in the opposite direction, from southeast to northwest – for example, from Hampton Roads to Chicago, or from Charlotte to Columbus. Those should be considered non-divertible routings.
- The other exception is trucks moving entirely within Virginia. These are moving between too many widely dispersed origins and destinations, over too short distances, to be effectively served by rail.

Fortunately, routings that should be considered non-divertible represent just 11.3 percent of trucks found on I-81. An estimated 88.7 percent of trucks have divertible routings.

Table 8. Percent of I-81 Trucks by Routing Type

	Percent of Trucks	Number With Divertible Routing	Number With Non-Divertible Routing
I-81 only through Virginia	40.5%	99.7%	0.3%
I-81 and Other Routes through Virginia	21.3%	98.1%	1.9%
I-81 to and from Virginia	32.1%	85.1%	14.9%
I-81 entirely within Virginia	6.0%	0.0%	100.0%
Total	100.0%	88.7%	11.3%

Source: CS analysis of Commonwealth truck surveys.

Table 9. Number of I-81 Trucks by Routing Type

	Trucks Per Day	Number With Divertible Routing	Number With Non-Divertible Routing
I-81 through Virginia	3,764	3,753	11
I-81 and Other Routes through Virginia	1,981	1,943	38
I-81 to and from Virginia	2,981	2,537	445
I-81 entirely within Virginia	557	-	557
Total	9,284	8,233	1,051

Source: CS analysis of Commonwealth truck surveys.

Commodity Exclusions

Regardless of distance, service, or rail technology, there are certain types of commodities that the railroads have not been, and will not be, competitive for. Certain automakers, for example, insist on trucking even for long-haul moves because of special handling requirements; shippers of live animals and other sensitive freight require the flexibility

that trucking provides; bulk commodities may need to move in smaller quantities than can be handled efficiently by rail, or to places not served by rail.

Global Insight Inc., working in support of the *Virginia Statewide Multimodal Freight Study*, reviewed the Virginia TRANSEARCH dataset and estimated that 15 percent of long-haul trucks operating on I-81 are carrying nondivertible commodities, based on commodity type and/or shipment size. These trucks are not considered divertible.

Table 10. Potentially Divertible I-81 Trucks

	Trucks Per Day	Number With Divertible Routing	Number With Divertible Routing and Divertible Commodity	Number Over 500 Miles	Number Under 500 Miles
I-81 through Virginia	3,764	3,753	3,190	3,190	-
I-81 and Other Routes through Virginia	1,981	1,943	1,652	1,623	29
I-81 to and from Virginia	2,981	2,537	2,156	465	1,692
I-81 entirely within Virginia	557	-	-	-	-
Total	9,284	8,233	6,998	5,278	1,720

After taking exclusions for divertible routings and divertible commodities into account, we are left with a total of 6,998 trucks – 5,278 moving over 500 miles, and 1,720 moving less than 500 miles – as potential candidates for truck to rail diversion.

Equipment Exclusions

Trucks come in a variety of shapes and sizes. Some types are highly amenable to transfer between truck and rail using conventional technologies. Others can be handled on rail, but require special technologies.

As previously discussed in Section 2.4, trucks hauling intermodal shipping containers on chassis and “dry van” trucks are excellent candidates for truck to rail diversion. Today, these are transferred easily between truck and rail using conventional equipment at a network of intermodal rail terminals throughout North America.

Figure 22. Truck Types Divertible to Rail With Conventional Technology



However, other types of trucks – liquid bulk tankers, dry bulk hopper, flatbeds, etc. – can be handled by rail using an operation known as “roll-on/roll-off,” or ro-ro, in which the trucks are driven onto and off of railcar platforms. Different types of terminals, equipment, and services are required to handle these different truck types. Ro-ro loading systems can involve splitting the train into several segments, to allow multiple points of loading and unloading; this is sometimes called “open technology.”

Figure 23. Truck Types Divertible to Rail With Open Technology



Limited sample information from the weigh station surveys, confirmed by additional observations, suggests that around two-thirds of trucks on I-81 are hauling either dry vans or intermodal shipping containers. The other third represents non-intermodal equipment.

At this stage of the analysis, we would not consider any trucks non-divertible solely on the basis of equipment type; however, it becomes important to distinguish between trucks that are potentially divertible using conventional technology, and trucks that are potentially divertible only with open technology.

Table 11. Potentially Divertible I-81 Trucks by Distance and Technology

	Trucks Per Day With Divertible Routing and Divertible Commodity	Potentially Divertible With Conventional Technology		Potentially Divertible With Open Technology	
		Over 500 Miles	Under 500 Miles	Over 500 Miles	Under 500 Miles
I-81 through Virginia	3,190	2,127	-	1,063	-
I-81 and Other Routes through Virginia	1,652	1,082	19	541	10
I-81 to and from Virginia	2,156	310	1,128	155	564
I-81 entirely within Virginia	-	-	-	-	-
Total	6,998	3,519	1,147	1,759	573

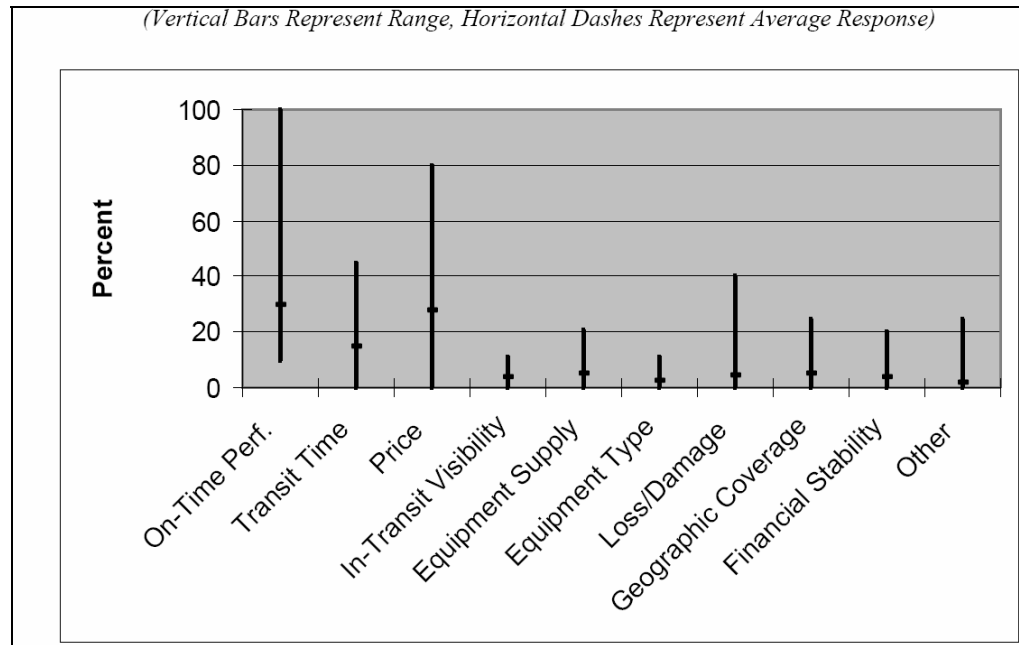
■ 3.2 Mode Selection, Competitive Factors, and Targeted Diversion Strategies

Given that the potential exists to divert up to 6,998 trucks per day from truck to rail, how can this be accomplished? The best place to start is with a clear understanding of mode selection, competitive factors, and targeted diversion strategies.

Mode Selection

Freight transportation is a service purchased by public and private shippers and receivers. These shippers and receivers, and their “third-party logistics providers,” typically make their purchasing decisions based on several factors, including: cost, speed, reliability, in-transit visibility, and safety and security. Which service a particular shipper chooses depends on the commodity, trade lane, and competitive advantage presented by rail versus trucking.

To understand why shippers choose different modes in the I-81 corridor, a series of shipper interviews was conducted as part of the *Northeast-Southeast-Midwest Corridor Marketing Study* (Reebie Associates, et al.).

Figure 24. I-81 Shippers' Freight Carrier Selection Criteria

Source: Northeast-Southeast-Midwest Corridor Marketing Study, Reebie Associates.

The interviews showed that **on-time performance** and **price** are the most important factors in determining whether a shipper will use truck or rail. **Transit time** – normally thought to be a critical factor in decision-making – is on average only half as important as on-time performance and price, and not significantly more important than **loss and breakage**.

Competitive Factors

Truck and rail obviously offer different types of services. Trucking specializes in reliable door to door service with high visibility and speed, usually at a higher cost than rail. Rail specializes in cost-effective point-to-point service, usually with lower speed and reliability, although the rail industry is working to compete in these areas.

Rail's major advantage over truck has historically been its lower costs. A rail service that offers lower costs than trucking, combined with comparable on-time performance and loss/breakage avoidance, can be extremely competitive with trucking, even if transit times are not as fast as trucking. This is how existing intermodal rail services over the Shenandoah and Piedmont line can capture significant market volumes, even with average travel speeds of 30 mph.

The public sector is in a unique position to affect the competitive balance between truck and rail, by virtue of its ability to construct infrastructure. By building and improving roads, it facilitates truck service. By developing publicly owned freight rail infrastructure,

or by partnering in the development of privately owned freight rail infrastructure, it facilitates rail service. Examples of direct public subsidies to freight shippers and carriers to encourage their use of one mode over another are rare, but there have been a few cases, most notably for failed container barge experiments.

This report considers that direct subsidies to rail shippers or railroads to make rail service more attractive compared to trucking are not feasible, due to basic questions of fairness and funding availability. However, the potential for the public to partner in the development of rail infrastructure – improving the reach of rail service, and enabling the railroads to offer it at a more attractive price due to their lower capital cost obligations – is clearly feasible. It happens today in Virginia, through Rail Enhancement Fund investments, and it happens in many other states as well.

Today, there is both truck and rail service in the I-81 corridor. Some shippers' needs are better met by rail than by truck; other shippers' needs are better met by truck than by rail. If rail can offer improved cost, reliability, and speed versus trucking, then some share of trucks could be expected to divert to rail. However, a reasonable analyst would never expect that **all** trucks potentially capable of diverting to rail would actually do so. This would require banning trucks from the I-81 corridor entirely, or heavily subsidizing rail to the point where its cost advantage becomes insurmountable, and neither is considered a feasible strategy.

It is, therefore, appropriate to reduce the number of potentially divertible trucks some amount, to reflect the competitive balance between trucking and rail – but by what amount, and based on what reasoning? The answers vary, because there is no “one-size-fits-all” strategy to achieve truck to rail diversion.

Targeted Diversion Strategies

Based on Table 11, it is easy to see that the truck to rail diversion opportunity for I-81 actually consists of multiple opportunities – some long-haul and some short-haul, some passing through Virginia and some moving freight to and from Virginia, some utilizing conventional technology and some requiring open technology. These different opportunities require different type of infrastructure and rail service strategies to achieve the maximum feasible truck to rail diversion. Five basic strategies have been identified, and every potentially divertible truck identified in Table 11 is addressed by one of them. The strategies are listed in Table 12 below.

Table 12. Strategies to Divert Trucks to Rail

Target Opportunity	Potentially Divertible Trucks Per Day (2008), From Table 11	Strategy to Divert Trucks to Rail
Long-haul (500+ miles) intermodal trucks moving through Virginia on I-81 only, or on I-81 in combination with other routes	2,127 + 1,082 = Up to 3,209	#1: Expand <u>conventional intermodal</u> rail terminals, network capacities, and services.
Long-haul (500+ miles) non-intermodal trucks moving through Virginia on I-81 only, or on I-81 in combination with other routes	1,063 + 541 = Up to 1,604	#2: Introduce <u>multistate network of open technology terminals</u> with conventional speed services, after implementing Strategy #1.
Long-haul (500+ miles) intermodal and non-intermodal trucks with an origin or destination in Virginia	310 + 155 = Up to 465	#3: Develop and enhance <u>Virginia intermodal and open technology terminals</u> , after implementing Strategy #1 and #2.
Short-haul (less than 500 miles) intermodal and non-intermodal trucks, passing through Virginia or with an origin or destination in Virginia; plus some additional potential to capture long-haul trips in this corridor; plus the opportunity to offer an overnight shuttle or “sleeper service” to trucks in this corridor	19 + 10 + 1,128 + 564 = up to 1,720 (short haul only) up to 4,910 (short and long haul)	#4: Introduce <u>higher-speed open technology</u> service in the Harrisburg-Knoxville Corridor, after implementing Strategies #1, #2, and #3.
Long-haul (500+ miles) intermodal and non-intermodal trucks moving through Virginia on I-81 only; these would be trucks arriving at key “cordon” points	2,127 + 1,063 = up to 3,190	#5: Introduce very high-speed open technology “ <u>truck intercept/truck shuttle</u> ” service through Virginia Option 5A: implement along with other strategies Option 5B: implement as “stand alone”

■ 3.3 Strategy #1: Expand Conventional Intermodal Rail Terminals, Network Capacities, and Services

Description

Strategy #1 aims to capture long-haul (500+) intermodal trucks passing through Virginia on I-81 only, or on I-81 in combination with other routes. The potential diversion opportunity is up to 3,209 trucks per day.

Strategy #1 envisions that the Piedmont and Shenandoah lines in Virginia would be improved to handle additional intermodal trains as well as longer trains; that complementary network improvements would be made in other states throughout the eastern and southeastern U.S. to match the capacity of these lines; and that key rail terminals would be upgraded or developed in other states to handle additional traffic. Intermodal rail terminals would operate in a “conventional” manner, using existing lift-on/lift-off equipment to transfer freight from truck to rail; and trains would operate at “conventional” speeds, meaning speeds currently typical for freight trains on the Piedmont and Shenandoah lines.

Conventional intermodal service is specifically targeted at containers and dry vans moving long distances (500+ miles) in high-density travel corridors between major freight hubs, which makes it the first choice of options to divert long-haul (500+ miles) intermodal trucks moving through Virginia.

Estimate of Feasibly Divertible Trucks Based on Price Elasticity

This strategy assumes that intermodal service would be expanded to a broader base of potential customers, through the introduction of new/expanded terminals and line-haul capacity. It does not assume significant changes in transit time or other performance characteristics. Since rail’s primary competitive advantage has historically been cost, it is possible to project the effects of offering this cost advantage to the full population of potentially divertible trucks in the I-81 corridor.

More specifically, if we assume that freight shippers generating I-81 truck trips are given the choice of rail at a lower cost, and that all other service factors are held constant, we can estimate the feasible diversion based on the price elasticity of market demand, and on the cost differentials between rail and truck services. The method is described below.

- This report finds that conventional intermodal rail could potentially divert up to 3,209 trucks per day in the I-81 corridor, in addition to current rail traffic. Some of these potentially divertible trucks already have the capability to use rail, but choose not to; others do not have easy access to rail services, so rail is not an option regardless of price. The exact splits between these markets are not known. For purposes of analysis, it is assumed that if all potentially divertible trucks were offered improved

conventional intermodal rail service, they would divert generally in proportion to the amount of cost savings offered by rail, all other factors assumed to be equal or of lesser importance.

- Earlier in this report (see Section 2.3), we suggested that while research does not point to a single best figure for price elasticity, a figure of -0.30 is reasonable. For trucking, this means a 1 percent increase in price results in a 0.3 percent loss of traffic. Looking at the choice between truck and rail costs, it might be expected that for each 1 percent cost savings offered by rail, 0.3 percent of trucks might divert to rail when offered the choice.
- According to a recent analysis by Cambridge Systematics,⁹ the cost of long-haul intermodal trucking in the I-81 corridor is approximately \$2.038 per unit mile, while the cost of intermodal rail is approximately \$1.388 per unit mile, including the cost of truck pick up and delivery at each intermodal rail terminal. Based on these price points, the estimated diversion would be 14 percent $((2.038-1.388)/1.388 \text{ times } 0.30)$ of all trucks, without any filtering for potential divertibility or market opportunity.

Applying the elasticity factor to different price points, one can see how changes in trucking and rail costs could affect the diversion rates.¹⁰

Table 13. Estimates of Feasible Truck to Rail Diversion Rates for Conventional Intermodal Service, Based on Costs

Rail Cost (Dollars per Unit Mile)	Truck Cost (Dollars per Unit Mile)					
	2.038	2.438	2.838	3.238	3.638	4.038
0.888	39%	52%	66%	79%	93%	100%
0.988	32%	44%	56%	68%	80%	93%
1.088	26%	37%	48%	59%	70%	81%
1.188	21%	32%	42%	52%	62%	72%
1.288	17%	27%	36%	45%	55%	64%
1.388	14%	23%	31%	40%	49%	57%
1.488	11%	19%	27%	35%	43%	51%
1.588	9%	16%	24%	31%	39%	46%
1.688	6%	13%	20%	28%	35%	42%
1.788	4%	11%	18%	24%	31%	38%
1.888	2%	9%	15%	21%	28%	34%

There are several important take-aways from Table 13.

⁹ *Benefit/Cost Analysis of the Crescent Corridor Program*, currently being finalized.

¹⁰ Note that this is not an estimate of total rail market share, because it does not include existing rail traffic. This relates only to the additional truck to rail diversion opportunity.

- It is reasonable to expect that over time, both trucking and rail costs will tend to increase, but rail costs should increase more slowly due to rail's fuel efficiency advantage over trucking. With current price points, the estimated rail diversion opportunity based solely on price advantage is 14 percent. Increasing at-the-pump fuel prices from \$3 to \$6 per gallon would result in a rail cost of \$1.53 per unit mile and a truck cost of \$2.48 per unit mile (see Table 2), and the estimated diversion would increase to between 17 and 18 percent. Increasing at-the-pump fuel prices from \$3 to \$9 per gallon would result in a rail cost of \$1.68 per unit mile and a truck cost of \$2.86 per unit mile (see Table 2), and the estimated diversion would increase to between 20 and 21 percent. So fuel price changes matter, but the effects may not be "game changing."
- There are practical limits to the diversion opportunity. For rail to capture more than 50 percent based on price differences, trucking costs would have to double while rail costs remain constant; or if trucking costs increase but do not double, rail costs would have to plummet. This is nearly impossible to imagine, because trucking and rail costs both depend on the same set of underlying factors – market willingness to pay and costs for fuel, wages, facilities and equipment – and changes in these factors will affect both modes. Also, intermodal rail requires trucks to deliver and pick up at rail terminals, so a significant share of the end-to-end "cost by rail" is actually truck cost.
- The diversion estimates are very sensitive to price assumptions. Even relatively small changes in price can produce significant changes in the estimates. This analysis is based on average rates, but in practice, trucking and rail costs vary widely depending on the commodity, travel lane and distance, competitive market conditions, and other factors. Further analysis would be needed to accurately reflect these important differences.
- Finally, we have relied on a general estimate of price elasticity. The best diversion models are based on corridor and commodity-specific elasticities not only for price, but also for changes in speed, reliability, and other factors. Because this information currently is not available, the diversion estimates presented in Table 13 should be used as a general guideline only.

Estimate of Feasibly Divertible Trucks Based on Business Strategy

Clearly, other factors besides price will be important in achieving significant truck to rail diversion. Most important among these will be on-time delivery, followed by transit time and loss/breakage avoidance. For rail, transit time improvements do not necessarily mean faster trains. For example, significant gains can be made by improving the frequency and reliability of rail service, by reducing the amount of time that freight is held at intermodal railyards, and by other business operational improvements. Given the importance of price in shipper decisions, it is difficult to imagine that any business operational strategy could succeed in diverting more than 50 percent of trucks to rail, but in our opinion a sound business operation could feasibly achieve diversion rates between 14 percent and 50 percent.

It is, therefore, important to estimate the diversion potential based on a model of railroad business strategy, rather than of transportation cost. In modeling railroad business strategy, the analysis can assume that rail carriers will attempt to price, schedule, and market their services to achieve certain target capture rates for particular services and markets. The diversion associated with these capture rates can then be estimated.

There is a developing precedent for this business strategy approach. The Commonwealth, through its Rail Enhancement Fund (REF), has made various investments in Virginia's rail system. Some of these investments include a unique partnership feature: in exchange for Commonwealth funding, the railroad guarantees a minimum level of truck to rail diversion, by contract. There are penalties for not meeting the target, so the railroad has an incentive to do what it takes to achieve the required level of diversion.

Expanding this approach to the larger issue of diversion potential in Virginia's I-81 corridor, business performance targets considered realistic and feasible have been established based on available data, Virginia and national studies, input from knowledgeable public and private parties, and best professional judgment. Ultimately, the "proof of the pudding" will be whether railroads are willing to commit to specific targets under contract. If a railroad commits, one can assume it will do its best to provide whatever mix of cost, speed, and reliability is necessary to hit the target. Conversely, if a railroad fails to commit, it is signaling that it cannot or will not do what is necessary to meet the target; under such conditions, the likelihood of the target actually being met is fairly low, and the target itself should not be considered feasible.

Intermodal rail improvements in Virginia's I-81 corridor, and in national rail lines feeding the corridor, are likely to benefit some geographies and truck moves more than others. For example, moves that can be handled entirely over an improved corridor, by a single railroad, would probably see the greatest benefit. Moves over a combination of improved and unimproved corridors, or involving multiple railroads, also should benefit, but not as much – in these cases, the critical bottleneck may not be the condition of the I-81 corridor rail system or performance over that system, but the interchange procedures between railroads, or the performance of a last mile connecting railroad far from Virginia. Therefore, a set of distinct "competitive corridors" can be defined as follows:

- **Highly competitive corridors for diversion.** Trucks moving to and from states that are directly served by the NS Crescent Corridor have the highest potential for truck to rail diversion, because these states would be served by an improved network operated by a single Class I railroad. These states include: New Jersey, Pennsylvania, Maryland, Virginia, Tennessee, North Carolina, South Carolina, Georgia, Alabama, Mississippi, and Louisiana.
- **Competitive corridors for diversion.** Trucks moving between NS Crescent Corridor states and states west of the Mississippi have significant potential for truck to rail diversion. The longer distances work strongly in favor of rail, but there can be extra handling and costs due to the involvement of multiple railroads. For NS to serve states west of the Mississippi River (except Missouri), traffic must be handled by, or over networks owned by, other railroads (principally Class 's), and interchanged via the

Meridian Speedway, New Orleans, and Memphis. These interchanges also allow NS to serve Mexican and Canadian traffic.

- **Possibly competitive corridors for diversion.** Trucks moving between NS Crescent Corridor states and New York/New England (east of the Hudson River) and the Florida peninsula (south of the Florida panhandle) have some potential for truck to rail diversion, but have the limitation of requiring partnership arrangements with smaller regional and short line railroad operators and networks.

For present purposes, the analysis assumes that an operating railroad would price, provide, and market its services to compete successfully for the following percentages of potentially divertible trucks:

- **Fifty percent diversion in highly competitive and competitive corridors.** The 50 percent figure represents an initial estimate of the market share that would provide an optimum balance between market size, demand, price, and cost to provide service; it reflects achievement of an equal balance of trucking and rail utilities.¹¹ Capture rates slightly higher than 50 percent may be attainable in practice, but going much higher would appear to cost advantages that rail will not be able to attain.
- **Seventeen percent in possibly competitive corridors.** For possibly competitive corridors, this figure is discounted to 17 percent, reflecting the fact that “last mile” connections are via regional and shortline railroads that may offer more limited service.

As shown in Table 14 following, around 48 percent of potentially divertible trucks are associated with highly competitive corridors, around 19 percent with competitive corridors, and around 33 percent with possibly competitive corridors. Applying the target rates described above, the number of feasibly divertible trucks using Strategy #1 is estimated at 1,255 per day, which represents 39 percent of potentially feasible trucks associated with this strategy.

Table 14. Estimates of Feasible Truck to Rail Diversion Rates for Conventional Intermodal Service, Based on Business Strategy

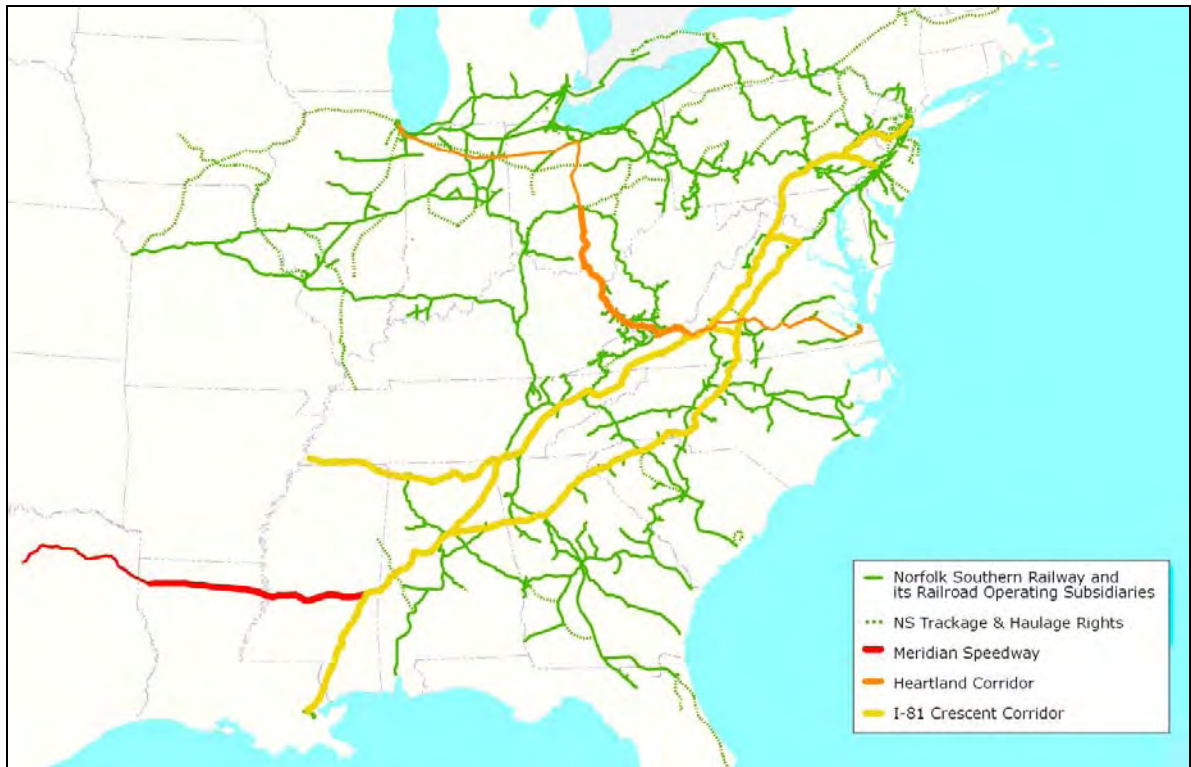
Type of Truck Trips	Share of Truck Trips	Potentially Divertible Trucks/ Day	Capture Rate	Feasibly Divertible Trucks/Day
Highly Competitive Corridors	48%	1,550	50%	775
Competitive Corridors	19%	601	50%	300
Possibly Competitive Corridors	33%	1,058	17%	180
Total	100%	3,209	39%	1,255

¹¹Earlier drafts of this report used 33 percent for competitive corridors. Further work suggested that 50 percent would be a more appropriate business target.

Recent and Current Proposals

Norfolk Southern, in partnership with Virginia and other states, has been exploring these issues for several years, and has formulated a rail improvement program known as the “Crescent Corridor.”

Figure 25. Norfolk Southern’s “Crescent Corridor” and Related Corridors



The geography of the Crescent Corridor extends well beyond I-81.

- Within Virginia, the Crescent Corridor includes the NS Shenandoah Line and NS Piedmont Line, along with the NS tracks connecting the two lines (between Manassas and Front Royal, and between Lynchburg and Roanoke).
- North of Virginia, it extends along the Shenandoah Line to Harrisburg, Pennsylvania; Philadelphia, Pennsylvania; and Newark/Elizabeth, New Jersey.
- South of Virginia, it extends south along the Shenandoah Line to Knoxville, Tennessee; Chattanooga, Tennessee; and Memphis, Tennessee; and Birmingham, Alabama; it also extends south along the Piedmont Line to Charlotte, North Carolina; Greenville, South Carolina; Atlanta, Georgia; and Birmingham, Alabama; and beyond Birmingham, it continues to Meridian, Mississippi and New Orleans, Louisiana.

- The NS Crescent Corridor links with other named NS service corridors (the Heartland Corridor and the Meridian Speedway), as well as the larger NS network. The NS network, in turn, connects to other major North American railroads, known as Class I railroads (CSX, Burlington Northern Santa Fe, Union Pacific, Kansas City Southern, Canadian Pacific, and Canadian National) as well as hundreds of smaller railroads.

The Crescent Corridor program aims to increase intermodal capacity and performance along the entire route through a combination of improvements: new track miles and passing tracks, upgrades to the hub terminal network, and technology improvements. Crescent Corridor terminals exist, or are planned for: Memphis, Tennessee; Birmingham, Alabama; Knoxville, Tennessee; Charlotte, North Carolina; Atlanta, Georgia; Hagerstown, Maryland/southeastern Pennsylvania; Harrisburg, Pennsylvania; Philadelphia, Pennsylvania; Bethlehem, Pennsylvania; and Newark/Elizabeth, New Jersey.

Virginia already has partnered with NS on the initial lower-cost initial phase program elements that meet Commonwealth requirements for demonstration of clear public benefits. Virginia is considering options to partner in additional elements of the program, as are other states along the full Corridor alignment.

There are several phases of work in Virginia:

- **Virginia Rail Enhancement Fund Project, Manassas to Front Royal.** On January 7, 2008, DRPT and NS executed a contract agreement for \$57 million in rail improvements to the I-81 corridor. The improvements are to benefit both freight and Virginia Railway Express passenger service in the Gainesville/Haymarket area. DRPT's press release of January 22, 2008 states:

"The project is funded as a partnership between Norfolk Southern and DRPT. It requires Norfolk Southern to deliver specific public benefits, including an increase in freight rail shipments which would, over the next fifteen years, remove 597,000 truck trips from Virginia highways ... These improvements will focus on the most congested portion of the I-81 rail corridor, between Manassas and Front Royal along I-66. While the overall needs for improvement in the I-81 rail corridor are extensive, the Manassas to Front Royal portion of the line is the most significant bottleneck for rail traffic, with limited opportunities for trains to pass each other and no signal system to control traffic ... New sidings and double track will be built, and existing sidings will be extended to accommodate today's longer freight trains. These improvements will also focus on train signalization and control..."

- **Virginia Projects, Phase I.** Expanding on the Manassas to Front Royal project, multiple projects comprising Phase I of the larger Crescent Corridor initiative have been identified through an iterative process of analysis and refinement. Both the Shenandoah and Piedmont lines are, for the most part, single track railroads. The major capacity constraint on single track railroads is the number and length of passing tracks, which allow trains moving in one direction to pass trains moving in the opposite direction. Almost all of the Crescent Corridor Phase I projects are to lengthen or construct new passing tracks or double track segments. This will allow the existing network to accommodate more trains as well as longer trains, with typical train lengths

increasing from 5,000 feet to 8,000 feet. The overall effect is to significantly increase railroad capacity, operating speed, and reliability, with a minimum of new track miles.

- **Virginia Projects, Phase II.** NS expects that following Phase I, there will be a second phase of Crescent Corridor improvements. Phase II projects focus on additional passing track and double track improvements, further increasing capacity, speed and reliability.

Extensive track improvements are planned for Virginia, but no terminal improvements. Improvements on some route segments also would support expansion of Virginia Railway Express (VRE) passenger service and future provision of TransDominion Express (TDX) passenger service. The current cost estimate for Crescent Corridor Phase I and II projects in Virginia is \$512 million.

Outside of Virginia, terminal improvements are planned for Alabama, Pennsylvania, and Tennessee. Track and other improvements are planned for Alabama, Mississippi, Georgia, Tennessee, South Carolina, North Carolina, West Virginia, Maryland, and Pennsylvania. The current cost estimate for Crescent Corridor projects outside of Virginia is \$1.620 billion.

NS is working with Virginia and other state partners to explore the potential for Federal funding of the Crescent Corridor. NS also has committed to partnerships in states that will feed rail traffic into the Crescent Corridor. Two recent examples are the Meridian Speedway and Patriot Corridor projects. The Meridian Speedway is a joint venture with the Kansas City Southern railroad, involving the upgrading and of KCS's route between Meridian, Mississippi and Shreveport, Louisiana. NS has committed \$300 million to this project, which greatly improves NS's service to/from Texas and Southern California. Another joint venture is the Patriot Corridor, where NS is investing \$120 million in 250 miles of railroad in New England owned by PanAm Railways. Improvements made to PanAm's routes will greatly enhance NS's ability to serve upstate New York and New England. These projects do not involve public investment at this time.

As part of planning for the Crescent Corridor, Norfolk Southern conducted its own market research by contacting potential customers. Based on customer feedback about the planned services, NS developed estimates of how many intermodal trucks it could divert to rail with the planned Crescent Corridor improvements. NS developed separate traffic forecasts for 63 different origin-destination movements between rail hubs from Texas to New Jersey. NS estimates that around 1.3 million intermodal units would be diverted from truck to rail in the year 2012.

The diversion of these intermodal units would affect highways in 13 states. Not all of the diversion would be in Virginia, but much of it would be. Within Virginia, the Crescent Corridor is projected to remove nearly 900,000 trucks annually from Virginia highways in the year 2012. This includes not only trucks using I-81, but also trucks using I-77, I-85,

I-95, I-66, and I-495. The number of trucks removed from I-81 varies from around 530,000 to 750,000 annually in 2012, depending on the segment.¹²

Table 15. Origins and Destinations for Trucks Diverted From I-81 by Crescent Corridor Program

From	To
Atlanta	Harrisburg, North Jersey, Philadelphia
Bethlehem	Birmingham, Dallas, Houston, Laredo
Birmingham	Bethlehem, Hagerstown
Charlotte	North Jersey, Philadelphia
Dallas	Bethlehem, Hagerstown
Hagerstown/SE PA	Birmingham, Dallas, Houston, Laredo, Memphis
Harrisburg	Atlanta, Knoxville, Memphis
Houston	Bethlehem, Hagerstown
Knoxville	Harrisburg, North Jersey, Philadelphia
Laredo	Bethlehem, Hagerstown
Memphis	Hagerstown, Harrisburg, North Jersey, Philadelphia
North Jersey	Atlanta, Charlotte, Knoxville, Memphis
Philadelphia	Atlanta, Charlotte, Knoxville, Memphis

Table 16. Trucks Diverted from I-81 by Crescent Corridor Program 2012

I-81 Segment	Diverted Trucks in Year 2012
Tennessee State Line to I-77 Junction	530,000
I-77 Junction to I-66 Junction	750,000
I-66 Junction to West Virginia State Line	640,000

To compare these figures with the estimate of feasibly divertible trucks, they must be converted from year 2012 to year 2008 (by discounting at 2.8 percent per year), then converting from annual to daily volumes (by dividing by 365). With these adjustments, the Crescent Corridor aims to divert the year 2008 equivalent of at least 1,300 trucks per day from I-81, depending on the segment.

¹²Benefit/Cost Analysis of the Crescent Corridor Program, currently being finalized. Routings were estimated based on the results of the Commonwealth's truck origin-destination surveys and on least-time paths where survey information was not conclusive.

Table 17. Trucks Diverted From I-81 By Crescent Corridor Program
2008 Equivalents

I-81 Segment	Annual Trucks, 2012	Equivalent Annual Trucks, 2008	Equivalent Daily Trucks, 2008
Tennessee State Line to I-77 Junction	530,000	474,573	1,300
I-77 Junction to I-66 Junction	750,000	671,566	1,840
I-66 Junction to West Virginia State Line	640,000	573,070	1,570

This is very consistent with the estimate of feasibly divertible trucks (1,255 per day in year 2008) presented in Table 14. In other words, the Crescent Corridor proposal appears to capture the feasibly divertible truck traffic associated with Strategy #1.

The CSX National Gateway proposal may have some effect on I-81 trucks. However, National Gateway is designed primarily for east-west service to and from seaports, which is a small share of I-81 corridor truck traffic.

Benefits and Costs

This strategy would divert a minimum of 1,255 trucks per day, or 458,075 per year, in the base analysis year. This represents 39.1 percent of potentially divertible trucks, 22.0 percent of long-haul through trucks on I-81, 13.5 percent of total trucks on I-81, and 3.2 percent of total AADT on I-81. The total number of units diverted through the year 2035 is estimated at 19.1 million. With a total cost in Virginia of \$512 million -- which could potentially be funded by some combination of private railroads, the Federal government, the Commonwealth, and users -- the cost in Virginia per diverted unit is \$26.82.

It is interesting to note that the estimated diversion rate of 13.5 percent of total trucks on I-81 is very close to the estimate of feasible diversion based solely on cost differentials between truck and rail (14 percent) from Table 13 previously. This means that three separate analysis methodologies -- internal market estimates by NS, cost differential analysis by CS, and corridor-level business strategy modeling by CS -- have converged on very similar diversion estimates for this Strategy.

Table 18. Benefits and Costs of Strategy #1

Evaluation Factor	#1
Potentially Divertible Trucks	3,209
Long-Haul through Trucks Diverted	1,255
Other Trucks Diverted	-
Total Trucks Diverted	1,255
Long-Haul through Trucks on I-81	5,711
Total Trucks on I-81	9,284
Total AADT on I-81	39,730
Share of Potentially Divertible Trucks Diverted	39.1%
Share of Long-Haul Through Trucks Diverted	22.0%
Share of Total Trucks Diverted	13.5%
Share of Total AADT Diverted	3.2%
Annual Units Diverted, 2008	458,075
Annual Units Diverted, 2035	965,496
Total Units Diverted, 2008-2035 (Millions)	19.1
Projected Cost Total (\$ Millions)	2,100
Projected Cost in Virginia (\$ Millions)	512
Cost in Virginia per Unit Diverted (\$)	26.82

Overall Feasibility Assessment

Looking at long-haul (500+ miles) trucks passing through Virginia on I-81 only or on I-81 in combination with other routes, it is considered feasible to divert 1,255 of these trucks per day. The NS Crescent Corridor proposal aims to divert around 1,300 long-haul trucks per day from I-81, and is a good fit to the available opportunity. It is particularly important to note that the NS estimate is based on input from existing and potential customers.

Conventional intermodal rail service has been well-established in North America for nearly 30 years, and is supported by an extensive system of intermodal terminals, network mileage, and services provided by numerous railroads acting both independently and in partnership. In September of 2009, the North American rail system handled around 1.0 million intermodal units; over the past four years, annual volumes have ranged from around 12 million to 15 million units. As previously noted, conventional intermodal also is well established in Virginia's I-81 Corridor, where the Piedmont and Shenandoah lines handled 500,000 units in 2006.

From a market and technical standpoint, the strategy is considered **feasible**. Issues yet to be resolved include: a) securing appropriate funding shares from the benefiting states, the Federal government, and private partners; and b) identifying and mitigating environmental impacts. These are discussed in Section 4.0 of this report.

Figure 26. Summary of Strategy #1

Strategy #1 envisions that the Piedmont and Shenandoah lines in Virginia would be improved to handle additional intermodal trains as well as longer trains; that complementary network improvements would be made in other states throughout the eastern and southeastern U.S. to match the capacity of these lines; and that key rail terminals would be upgraded or developed in other states to handle additional traffic. Intermodal rail terminals would operate in a “conventional” manner, using existing lift-on/lift-off equipment to transfer freight from truck to rail; and trains would operate at “conventional” speeds, meaning speeds currently typical for freight trains on the Piedmont and Shenandoah lines. NS has already proposed to improve conventional intermodal service over these lines as part of its multistate “Crescent Corridor” program.	
Potentially divertible trucks	3,209 / day
Capture rate	Feasible to divert up to 39% based on capturing 50% of traffic in highly competitive corridors, 50% in competitive corridors, and 17% of traffic in possibly competitive corridors.
Feasibly divertible trucks	1,255 / day
Proposals	The NS Crescent Corridor proposal aims to divert at least 1,300 trucks per day (2008 equivalent) from I-81, based on direct information from potential customers. This would fully capture the available market opportunity.
Cost estimate	Total construction cost is \$2.1 billion, with \$512 million in Virginia.
Risk Factors	Requires funding of improvements in other states, which is not yet secured. Environmental review not yet performed. Delivery of anticipated benefits not guaranteed.
Key Findings	The North American rail system currently handles about 13 million units annually, so the service capability and technology is well-established and proven. The required improvements, performance results, and costs are known. From a market and technical standpoint the strategy is considered feasible.

■ 3.4 Strategy #2: Introduce Multistate Network of Open Technology Terminals

Description

Strategy #2 aims to capture long-haul (500+ miles) non-intermodal trucks passing through Virginia on I-81 only, or on I-81 in combination with other routes. The potential diversion opportunity is up to 1,604 trucks per day.

As previously discussed, standard intermodal rail services do not accommodate non-intermodal trucks, but there are other rail services that do. The key is how the train is loaded and unloaded. Instead of lifting freight onto and off of the railcar, trucks and/or trailers are actually driven onto and off of railcars. This is known as roll-on/roll-off, or ro-ro, operation. With ro-ro, it does not matter what the truck is or what it is carrying – if it has wheels, it can be loaded and carried, provided the trailer unit itself is structurally sufficient. The operation is similar to a ferry boat, but on land.

Ro-ro rail operations are fairly well established in Europe, but not in North America. In North America, open technology was first introduced by CSX in the mid-1990s as the “Iron Highway.” Iron Highway technology involves a train comprised of flatcars and

multiple power units at different locations, so that the train can be separated into multiple parts; loading ramps are positioned at breaks in the train, and trucks and trailers are driven on and off. CP subsequently acquired CSX's equipment and started the "ExpressWay" service between Montreal and Toronto (340 miles) in 2006. CP later extended ExpressWay service to Detroit (another 230 miles) in 2002, with five terminals (Montreal, two in Toronto, Windsor, and Detroit) and two trains per day in each direction, six days a week, with up to 90 platforms per train. CP has reported typical loading times of less than one hour for a 90-car consist. ExpressWay carries only the truck trailers, not the drivers – there are no passenger accommodations.

Open technology was originally conceived as a way to make rail more competitive with trucking over short distances, by reducing load and unload times and offering competitive end-to-end speeds. As the rail lines paralleling the Crescent Corridor offer average travel speeds of 30 mph or less, high-speed service is not an option without significant line improvements, and it could not offer competitive short-haul service. But even with current line speeds, there is a significant opportunity to divert long-haul (500+ miles) non-intermodal trucks moving through Virginia on I-81 only, or on I-81 plus other routes.

Strategy #2 is envisioned as a direct follow-on to implementation of the Crescent Corridor. Each Crescent Corridor intermodal hub would be upgraded with open technology capabilities and appropriate rail equipment. Some additional line improvements also might be needed, although it is hoped that most of what is needed will be provided as part of the Crescent Corridor program. Open technology would operate at the same service speeds as other freight on the Piedmont and Shenandoah lines (around 30 mph).

Figure 27. Canadian Pacific's "ExpressWay" Service



By design, Strategy #2 is a lower-cost, lower-risk approach to introducing a new technology and a new market opportunity to U.S. railroading. It avoids the need for major investments in network speed improvements. In doing so, it deliberately foregoes the opportunity to capture short-haul traffic and other opportunities; higher-speed open technology options are addressed in Strategy #4.)

Estimate of Feasibly Divertible Trucks Based on Business Strategy

For established transportation services such as trucking and conventional intermodal rail, past practice provides some useful guidance in estimating market demand, service costs, and potential diversion. For services that do not exist, it is more difficult to anticipate service costs and potential diversion.

Strategy #2 is essentially an upgrade to the Crescent Corridor program. Like the Crescent Corridor, it is a conventional speed service, aimed at diverting long-haul trucks passing through Virginia on I-81 only or on I-81 in combination with other routes. The service network is identical. The only difference is that the service targets non-intermodal equipment rather than intermodal equipment.

Viewed as a logical extension of the Crescent Corridor program, it is likely that the business model and diversion targets might be similar to those for intermodal: 50 percent of potentially divertible traffic in highly competitive corridors, 50 percent in competitive corridors, and 17 percent in possibly competitive corridors. If so, the resulting estimate is that of the 1,604 potentially divertible trucks, around 628 are considered feasibly divertible.

Table 19. Estimates of Feasible Truck to Rail Diversion Rates for Conventional Speed Open Technology, Based on Business Strategy

Type of Truck Trips	Share of Truck Trips	Potentially Divertible Trucks/Day	Capture Rate	Feasibly Divertible Trucks/Day
Highly Competitive Corridors	48%	775	50%	388
Competitive Corridors	19%	300	50%	150
Possibly Competitive Corridors	33%	529	17%	90
Totals	100%	1,604	39%	628

If introduced, it could be expected that conventional speed open technology services also would handle some amount of intermodal traffic. The trains would be operating between the same hubs, and over the same networks, as conventional intermodal trains. Open technology trains might offer more attractive schedules, useful “overflow” capacity during periods of peak demand, or possibly – although this is far from certain – more attractive prices. In such cases, intermodal units at a given rail hub might load onto open technology trains rather than conventional intermodal trains. However, open technology operating at conventional speeds in long-haul corridors would not offer significantly better service than conventional intermodal rail, and would not significantly improve rail’s ability to capture long-haul intermodal trucks passing through Virginia.

Recent and Current Proposals

The *Northeast-Southeast-Midwest Corridor Marketing Study* explored the possibility of implementing open technology over the entire Virginia rail network and the larger multistate rail network, with multiple terminals (Knoxville, Tennessee; Harrisburg, Pennsylvania; Elizabeth, New Jersey; Philadelphia, Pennsylvania; Alexandria, Virginia; Atlanta, Georgia; Huntsville, Alabama; and Meridian, Mississippi). Unfortunately, the study design makes it difficult to isolate the specific contributions of open technology.

This report prefers to break the diversion opportunity down into more manageable pieces. With respect to open technology, this means starting with the “low hanging fruit.” The easiest, least expensive and probably least risky way to introduce open technology is to simply build the capability into the existing and planned intermodal network, and to operate over the tracks built to serve that network at current typical speeds.

No formal proposals or cost estimates exist to describe the investments needed, but we estimate an order-of-magnitude cost of around \$575 million to upgrade the Crescent Corridor network for open technology – \$25 million for upgrades and equipment at each of 13 hubs, plus \$250 million for potential line work in Virginia.

Benefits and Costs

This strategy would divert a minimum of 628 trucks per day, or 229,220 per year, in the base analysis year. This represents 39.2 percent of potentially divertible trucks, 11.0 percent of long-haul through trucks on I-81, 6.8 percent of total trucks on I-81, and 1.6 percent of total AADT on I-81. The total number of units diverted through the year 2035 is estimated at 9.6 million. With a total cost in Virginia of \$250 million -- which could potentially be funded by some combination of private railroads, the Federal government, the Commonwealth, and users – the cost in Virginia per diverted unit is \$26.17. The cost estimate assumes that Strategy #1 already is in place; otherwise, costs would be significantly higher.

Table 20. Benefits and Costs of Strategy #2

Evaluation Factor	#2
Potentially Divertible Trucks	1,604
Long-Haul through Trucks Diverted	628
Other Trucks Diverted	-
Total Trucks Diverted	628
Long-Haul through Trucks on I-81	5,711
Total Trucks on I-81	9,284
Total AADT on I-81	39,730
Share of Potentially Divertible Trucks Diverted	39.2%
Share of Long-Haul Through Trucks Diverted	11.0%
Share of Total Trucks Diverted	6.8%
Share of Total AADT Diverted	1.6%
Annual Units Diverted, 2008	229,220
Annual Units Diverted, 2035	483,133
Total Units Diverted, 2008-2035 (Millions)	9,551,450
Projected Cost Total (\$ Millions)	575
Projected Cost in Virginia (\$ Millions)	250
Cost in Virginia per Unit Diverted (\$)	26.17

Overall Feasibility Assessment

While there are successful precedents for open technology services in Europe and Canada, it has failed once in the U.S. market and since then has not drawn the interest of U.S. railroads. Because of its limited track record, we are unwilling to find that Strategy #2 is feasible – but it is considered **potentially feasible** and worth more detailed investigation. The technology is relatively straightforward; the incremental improvements required are relatively minor, especially when compared to previous open technology investigations; and the potential diversion benefits are significant.

Figure 28. Summary of Strategy #2

Strategy #2 is envisioned as a direct follow-on to implementation of the Crescent Corridor. Each Crescent Corridor intermodal hub would be upgraded with open technology capabilities and appropriate rail equipment. Some additional line improvements also might be needed, although it is hoped that most of what is needed will be provided as part of the Crescent Corridor program. Open technology would operate at the same speeds as other freight on the Piedmont and Shenandoah lines (around 30 mph).	
Potentially divertible trucks	1,604 / day
Capture rate	Potentially feasible to divert up to 39% based on capturing 50% of traffic in highly competitive corridors, 50% in competitive corridors, and 17% of traffic in possibly competitive corridors.
Feasibly divertible trucks	628 / day
Proposals	None currently. The concept has been explored in previous Commonwealth studies.
Cost estimate	We estimate \$375 million for improvements and equipment 13 hubs (\$25 million each), plus \$250 million for line work in Virginia, but more detailed analysis may identify the need for additional line improvements.
Risk Factors	No precedent in U.S. markets. Possibility that costs may be higher than estimated. Requires funding of improvements in other states, which is not yet secured. Environmental review not yet performed. Delivery of anticipated benefits not guaranteed. Requires implementation of Strategy #1.
Key Findings	Open technology operates successfully in Europe and Canada. This strategy is considered potentially feasible.

■ 3.5 Strategy #3: Develop and Enhance Intermodal and Open Technology Terminals in Virginia

Description

Strategy #3 aims to capture long-haul (500+ miles) intermodal and non-intermodal trucks that have an origin or destination in Virginia. The potential diversion opportunity is up to 465 trucks per day.

Strategies #1 and #2 will accommodate the diversion of long-haul truck trips passing through Virginia. Long-haul truck trips that originate or terminate in Virginia, however, would not be affected, because Virginia intermodal hubs are not part of the service network. Strategy #3 envisions that following implementation of Strategies #1 and #2, intermodal rail terminals in Virginia are developed, enhanced, and integrated into the Crescent Corridor network.

NS has, or will have, two intermodal terminals in Virginia that are potentially accessible to the Crescent Corridor: the existing terminal at Front Royal (the Virginia Inland Port), which handles traffic to and from Virginia Port Authority terminals in Hampton Roads;

and the planned facility at Elliston (near Roanoke), which is to be developed as part of the Heartland Corridor.

Under Strategy #3, these hubs would be upgraded and enhanced to accommodate both intermodal and open technology traffic handled along the Shenandoah Line (in the case of Elliston) and both the Shenandoah and Piedmont lines (in the case of Front Royal).

Estimate of Feasibly Divertible Trucks Based on Business Strategy

Strategy #3 adds two more hubs to the Crescent Corridor network. Virginia origin-destination trips tend to be more focused on travel within highly competitive and competitive corridors, and less within possibly competitive corridors, so the capture rate for highly competitive corridors (50 percent) is applied to all traffic.

Table 21. Estimates of Feasible Truck to Rail Diversion Rates for Virginia Terminals, Based on Business Strategy

Type of Truck Trips	Potentially Divertible Trucks/Day	Capture Rate	Feasibly Divertible Trucks/Day
All	465	50%	233

Recent and Current Proposals

As previously noted, NS has not planned to integrate the Virginia Inland Port facility at Front Royal into the Crescent Corridor network. NS plans to construct an intermodal facility at Elliston as part of the Heartland Corridor, but has not planned to integrate it into the Crescent Corridor service network.

NS reports that both facilities would require substantial upgrades to accommodate Crescent Corridor intermodal service, as well as upgrades to provide open technology. No formal cost estimates have been prepared, so for present purposes we are assuming \$25 million at each terminal for intermodal upgrades and \$25 million for open technology upgrades, for a total cost of \$100 million. All of the investment required is in Virginia.

Benefits and Costs

This strategy would divert a minimum of 233 trucks per day, or 85,045 per year, in the base analysis year. This represents 50.1 percent of potentially divertible trucks, 0.0 percent of long-haul through trucks on I-81, 2.5 percent of total trucks on I-81, and 0.6 percent of total AADT on I-81. The total number of units diverted through the year 2035 is estimated at 3.5 million. With a total cost in Virginia of \$100 million -- which could potentially be

funded by some combination of private railroads, the Federal government, the Commonwealth, and users – the cost in Virginia per diverted unit is \$28.22. The cost estimate assumes that Strategies #1 and #2 are already in place; otherwise, costs would be significantly higher.

Table 22. Benefits and Costs of Strategy #3

Evaluation Factor	#3
Potentially Divertible Trucks	465
Long-Haul through Trucks Diverted	-
Other Trucks Diverted	233
Total Trucks Diverted	233
Long-Haul through Trucks on I-81	5,711
Total Trucks on I-81	9,284
Total AADT on I-81	39,730
Share of Potentially Divertible Trucks Diverted	50.1%
Share of Long-Haul Through Trucks Diverted	0.0%
Share of Total Trucks Diverted	2.5%
Share of Total AADT Diverted	0.6%
Annual Units Diverted, 2008	85,045
Annual Units Diverted, 2035	179,252
Total Units Diverted, 2008-2035 (Millions)	3,543,771
Projected Cost Total (\$ Millions)	100
Projected Cost in Virginia (\$ Millions)	100
Cost in Virginia per Unit Diverted (\$)	28.22

Overall Feasibility Assessment

Virginia has not been seen as a key origin-destination hub for Crescent Corridor traffic. The service is designed to run between hubs that are located in, or within a two-hour drive of, major national population centers. Knoxville to the south of Virginia and Hagerstown and Harrisburg to the north of Virginia are logical hubs. Roanoke has not been seen as a major hub because of its modest local population and distance from other urbanized areas; Front Royal has not been seen as a major hub because it has been dedicated to VPA traffic, and because it would largely duplicate capacity at being provided at Hagerstown.

Still, with so much potential rail service through Virginia, it seems a missed opportunity not to have the service stop in Virginia, so that Virginia's shippers and receivers can benefit from the choice of rail. Because of the uncertainty and limited size of the market, we are unwilling to find that Strategy #3 is feasible – but it is considered **potentially feasible** and worth more detailed investigation.

Figure 29. Summary of Strategy #3

NS has, or will have, two intermodal terminals in Virginia that are potentially accessible to the Crescent Corridor: the existing terminal at Front Royal (the Virginia Inland Port), which handles traffic to and from Virginia Port Authority terminals in Hampton Roads; and the planned facility at Elliston (near Roanoke), which is to be developed as part of the Heartland Corridor. Under Strategy #3, these hubs would be upgraded and enhanced to accommodate both intermodal and open technology traffic.	
Potentially divertible trucks	465 / day
Capture rate	Potentially feasible to divert up to 50%, based on capturing 50% of traffic in highly competitive corridors and 50% in competitive corridors.
Feasibly divertible trucks	233 / day
Proposals	No current plans to integrate these hubs into Crescent Corridor services.
Cost estimate	We estimate \$100 million for improvements -- \$25 million at each hub for open technology and \$25 million at each hub for upgraded intermodal capacity.
Risk Factors	Demand may not reach "critical mass." Environmental review not yet performed. Delivery of anticipated benefits not guaranteed. Requires implementation of Strategies #1 and #2.
Key Findings	This strategy is considered potentially feasible.

■ 3.6 Strategy #4: Introduce Higher-Speed Open Technology

Description

Assuming improvements are in place to divert long-haul intermodal trucks passing through Virginia (Strategy #1), long-haul non-intermodal trucks passing through Virginia (Strategy #2), and long-haul trucks of all kinds that originate and terminate in Virginia (Strategy #3), the next question is: how can we potentially divert shorter-haul trucks moving less than 500 miles from I-81?

The recommended strategy is higher-speed open technology. If the train can provide end-to-end performance comparable to trucking, it may be competitive at distances less than 500 miles. CP's Expressway's scheduled service between Montreal and Toronto is around seven hours for a 340-mile trip, or around 50 mph. Current freight train speeds over the Piedmont and Shenandoah lines average less than 30 miles an hour, but one might hope for an I-81 corridor service that reaches 60-70 mph, matching the line-haul speed of over the road trucking. Such a service could potentially attract short-haul (less than 500 miles) intermodal and non-intermodal trucks.

The project, as envisioned, would involve upgrading the Shenandoah line, as well as connecting lines in Tennessee and Pennsylvania, to accommodate 60-70 mph open technology train service. With Virginia rail hubs at Front Royal and Roanoke, the higher-speed service network should extend at least as far south as Knoxville, and at least as far north as Harrisburg and possibly Bethlehem. The speed improvements would require

extensive double-track and passing track construction, and probably geometric improvements as well.

Market Opportunities

Higher-speed open technology could address three potential market opportunities: short-haul traffic; long-haul traffic originating and terminating in Harrisburg and Knoxville; and long-haul traffic with other origins and destinations which might use rail only for the portion of the trip between Harrisburg and Knoxville.

Short Haul Opportunity

For short-haul, the potential diversion opportunity is up to 1,720 trucks per day. Remembering that truck moves between origins and destinations in Virginia were previously excluded from consideration, the vast majority of potentially divertible short-haul traffic on I-81 is moving between Tennessee and Virginia or between Pennsylvania and Virginia. Almost none of the short-haul traffic on I-81 is moving between Tennessee and Pennsylvania; the distance between Knoxville and Harrisburg is around 540 miles, which is over the 500-mile threshold, and is considered divertible by conventional speed services.

The primary challenges in diverting short-haul trips are: 1) they want to go a lot of places the railroad does not go; and 2) they may not want to go very far. A trip from Knoxville to Front Royal (around 420 miles) or Harrisburg to Roanoke (around 300 miles) can go nearly the entire distance by rail, and may be a good diversion candidate. A trip from Knoxville to Richmond (around 440 miles) can only go 250 miles by rail (as far as Roanoke), and then has to drive the rest of the way, and is probably a very poor diversion candidate. A trip from Harrisburg to Charlottesville (around 240 miles) can only go 120 miles by rail (as far as Front Royal) and is a very poor diversion candidate. A trip from Charlotte to Harrisonburg (around 290 miles) has no high-speed rail option.

To do a proper market estimate of the short-haul diversion opportunity, one would want to know the specific city-to-city routings of short-haul traffic, the specific trucking costs associated with that traffic, and the specific costs of an alternative high-speed open technology rail service. Unfortunately, none of this information currently is available. For present purposes, we assume that perhaps 10 percent of I-81 short-haul trucks are of the hub-to-hub type and may be feasible to divert; we assume the remainder are making trips that are either too short to divert, or are traveling between points that are not well served by rail. This is a provisional estimate only and should be confirmed or modified by further analysis. The estimate is intended only to provide an order-of-magnitude sense of the scale of the opportunity, for comparison with other strategies in this report.

Improving the Capture Rate for Harrisburg-Knoxville Market Traffic

Besides short-haul trucks, higher-speed open technology service between Knoxville and Hagerstown might possibly improve the capture rate for both intermodal and non-intermodal trucks in that specific corridor. In 2007, there were an estimated 544 trucks per day moving between these two hubs. Some of these trucks would be diverted by conventional intermodal and open technology services, but higher-speed open technology service might add 25 percent to the market capture rate for this specific service pair.

Potential for "Sleeper Service"

There is one other interesting market opportunity for a high-speed open technology service, and possibly a more substantial one. At 60 mph, the travel time between Knoxville and Harrisburg (540 miles) is around 9 hours. Federal hours of service requirements call for over-the-road truckers to rest for at least 11 hours in every 24-hour period. It is not inconceivable that a trucker, approaching Knoxville near the expiration of his/her hours of service, might want to load onto a train and be carried to Harrisburg while enjoying their mandatory rest hours. The key, of course, would be to carry the truck, the cab, and the driver together. As previously noted, freight trains currently do not have provisions to carry drivers, so this would require further investigation. There are approximately 3,190 long-haul trucks, both intermodal and non-intermodal, passing through Virginia each day using I-81 only; nearly all of them go through both Knoxville and Harrisburg, and some could potentially be captured by a "Sleeper Service."

Nothing like this service exists today, so accurately estimating its capture rate would require an extensive survey research program. For now, we can offer a reasonable order-of-magnitude estimate of its likely upside potential.

- The potential market is long haul trucks using I-81 end-to-end through Virginia, excluding trucks moving between Knoxville and Harrisburg (whose diversion is estimated separately), and excluding long haul trucks using I-81 end-to-end which are previously diverted by Strategy #1 or #2. Of the 3,190 long haul through trucks using I-81 only, around 544 are moving between Knoxville and Harrisburg, while an estimated 1,248 would be diverted under Strategies #1 and #2.¹³ This leaves 1,398 trucks as potential candidates for diversion to a sleeper service.
- A truck would have to arrive at Knoxville or Harrisburg with 2 hours or less of driving time on his/her daily "clock." Some drivers would be able to schedule their trips to meet these windows, but other trips may begin or end at distances that would put them at Knoxville or Harrisburg at the beginning, or in the middle, of their clock. With

¹³ Strategies #1 and #2 divert a combined total of 1,883 trucks, all of which are long haul through Virginia. Around two-thirds of the diverted trucks are using I-81 only; the other one-third are using I-81 in combination with other routes.

random arrival times, the probability that any truck might arrive at either hub with 2 hours or less remaining on the clock is 2 out of 11, or 18 percent. Truckers do have some flexibility to schedule their trips, and perhaps as many as 50 percent might be able to meet this window.

- Of these arriving trucks, a maximum of 50 percent might choose to utilize a sleeper service. This requires the fulfillment of several conditions, none of which can be proven at this point: that such a service would be competitively priced; that such a service would be conveniently scheduled and available to truckers when they arrive at the hubs; and that such a service might someday be legal. This represents a very aggressive capture rate assumption for a service that is currently unproven.
- The capture rate is estimated at 25 percent (50 percent arriving at the right times, times 50 percent choosing to use the service) of eligible trucks. There are an estimated 1,398 eligible trucks, so the total diversion potential is 349 trucks.

Combined Market Opportunity

Summing these three potential markets, the combined estimate of feasibly divertible trucks for a higher-speed open technology service is around 657 per day.

Table 23. Estimates of Feasible Truck to Rail Diversion Rates for Higher-Speed Open Technology

Type of Truck Trips	Potentially Divertible Trucks/Day	Capture Rate	Feasibly Divertible Trucks/Day
Short-Haul Trucks	1,720	10%	172
Long-Haul I-81 Only Trucks, Knoxville-Harrisburg	544	25%	136
"Sleeper Service" for Other Long-Haul I-81 Only Trucks	2,646	25% of 1,398	349
Total	4,910	13.4%	657

Recent and Current Proposals

High-speed open technology service between Knoxville and Harrisburg has been recommended by rail service advocates, but no formal proposals have been put forth by any parties. Again, probably the deepest formulation of the open technology network concept was in the *Northeast-Southeast-Midwest Corridor Marketing Study*.

When asked to provide an order-of-magnitude cost estimate to upgrade the Shenandoah Line for 60-70 mph service, NS responded that the costs would likely be in the \$1 to \$2 billion dollar range, within Virginia alone. For present purposes, we assume \$1.5 billion total, with \$1.25 in Virginia and \$250 million in Tennessee and Pennsylvania.

Benefits and Costs

This strategy would divert a minimum of 657 trucks per day, or 239,979 per year, in the base analysis year. This represents 13.4 percent of potentially divertible trucks, 8.5 percent of long-haul through trucks on I-81, 7.1 percent of total trucks on I-81, and 1.7 percent of total AADT on I-81. The total number of units diverted through the year 2035 is estimated at 10.0 million. With a total cost in Virginia of \$1.25 billion -- which could potentially be funded by some combination of private railroads, the Federal government, the Commonwealth, and users -- the cost in Virginia per diverted unit is \$125.00. The cost estimate assumes that Strategies #1, #2, and #3 are already in place; otherwise, costs would be significantly higher.

Table 24. Benefits and Costs of Strategy #4

Evaluation Factor	#4
Potentially Divertible Trucks	4,910
Long-Haul through Trucks Diverted	485
Other Trucks Diverted	172
Total Trucks Diverted	657
Long-Haul through Trucks on I-81	5,711
Total Trucks on I-81	9,284
Total AADT on I-81	39,730
Share of Potentially Divertible Trucks Diverted	13.4%
Share of Long-Haul Through Trucks Diverted	8.5%
Share of Total Trucks Diverted	7.1%
Share of Total AADT Diverted	1.7%
Annual Units Diverted, 2008	239,979
Annual Units Diverted, 2035	505,809
Total Units Diverted, 2008-2035 (Millions)	9,999,759
Projected Cost Total (\$ Millions)	1,500
Projected Cost in Virginia (\$ Millions)	1,250
Cost in Virginia per Unit Diverted (\$)	125.00

Overall Feasibility Assessment

A reasonably fast (50 mph) open technology service has been successfully operating between Montreal and Toronto. Both are huge metropolitan areas and major magnets for freight movement. On its face, the Knoxville-Roanoke-Front Royal-Harrisburg corridor would not seem to offer the same kind of market potential. Nevertheless, there is a significant demand for short-haul trips to and from Virginia in the I-81 corridor. We suspect that to truly serve such a market effectively, a much larger network of comparably high-speed freight rail lines and terminals would be needed, to get closer to the truck origins and destinations in Virginia. The service could increase the rate of diversion for trucks moving between Knoxville and Harrisburg markets. Higher-speed open technology also might offer a “sleeper service” for truckers on their hours of rest.

One interesting feature of this strategy is that it targets different types of customers. For the short-haul opportunity and the Knoxville-Harrisburg market opportunity, the customer – that is, the entity deciding whether to use truck or rail – is the party making the logistics arrangements, which may be the shipper or a third party. For the “sleeper service” opportunity, the customer – the entity making the decision to stop at the rail yard or keep driving – is the trucker. So the cost of the rail service needs to be a good fit to what the trucker can afford as an out-of-pocket expense.

- If the drive from Knoxville to Harrisburg is 540 miles, the trucker’s out-of-pocket fuel cost is probably close to \$300 (at 5.4 mpg and \$3.00 per gallon.) If the railroad could offer the service at \$300, the trucker would incur the same out-of-pocket costs on the highway or on the railroad – and would in many cases choose rail, because rail also provides a time savings benefit. Unfortunately, rail is typically priced closer to \$1 per mile, so a Knoxville to Harrisburg trip might cost \$500 or more.
- At a cost of \$500 or more, the only reason a trucker would choose to use rail is to save both fuel cost and time. In FHWA’s Highway Economic Requirements System (HERS) model, the value of a trucker’s time has been estimated at around \$36 for combination trucks, and the equivalent time savings value to the trucker is \$324 (9 hours at \$36). So in theory, the avoided fuel costs and the value of time savings might cover the rail cost. However, the value of time savings is a theoretical value only – it has no real “in pocket” value unless the trucker can turn the time savings into cash, by making more trips or earning premiums for faster delivery. This is a complex question requiring substantially more detailed investigation than this report can provide. Our general sense is that the service might be attractive in some cases, but not in others – hence our recommendation to assume a relatively high capture rate for the present analysis.
- The main limitation of this concept is simply that the base of traffic it might potentially divert is fairly small. The base is small because: (a) not all I-81 trucks are divertible; (b) not all divertible I-81 trucks are using I-81 end-to-end through Virginia and passing through both Knoxville and Harrisburg; and (c) around half the trucks that might use this service could be diverted by Strategies #1, #2, and #3, which offer higher levels of proven or potential feasibility as well as lower costs.

Combined, these three market opportunities are not insubstantial. Neither are the potential costs; this strategy has one of the higher costs per diverted unit, even though we assume the possibility of high market capture rates. This opportunity would require substantially more analysis to conclusively determine its feasibility, so its **feasibility is unknown** at this time.

Figure 30. Summary of Strategy #4

Strategy #4 would involve upgrading the Shenandoah line, as well as connecting lines in Tennessee and Pennsylvania, to accommodate 60-70 mph open technology train service. With Virginia rail hubs at Front Royal and Roanoke, the higher-speed service network should extend at least as far south as Knoxville, and at least as far north as Harrisburg and possibly Bethlehem. The speed improvements would require extensive double-track and passing track construction, and probably geometric improvements as well.	
Potentially divertible trucks	4,910 / day
Capture rate	Possibly feasible to divert up to 10% of short-haul trucks, 25% of Harrisburg-Knoxville trucks, and 9% of long-haul trucks (if "sleeper service" can be offered)
Feasibly divertible trucks	657 / day (172 from short-haul, 136 from Harrisburg-Knoxville markets, 349 from "sleeper service")
Proposals	No current plans for these services.
Cost estimate	Unknown. We estimate \$1 billion to upgrade the Piedmont Line in Virginia to higher speed, plus \$250 million for matching improvements in TN and PA.
Risk Factors	<p>Market capture rate estimates are speculative at this point, and depend on adoption of non-traditional logistics by truckers and shippers. We assume high rates of market capture that may not be realized in practice.</p> <p>Costs are unknown.</p> <p>Environmental review not yet performed.</p> <p>Delivery of anticipated benefits not guaranteed.</p> <p>Requires implementation of Strategies #1, #2, and #3.</p> <p>Requires funding of improvements in other states.</p>
Key Findings	The feasibility of this strategy is unknown.

■ 3.7 Strategy #5: Implement Very High-Speed Truck Intercept / Truck Shuttle Service

Strategy #5 aims to establish a very high-speed (perhaps 120 mph) open technology service between Knoxville and Harrisburg. Such a service might potentially attract intermodal and non-intermodal trucks that are passing through Virginia using I-81. Such a service would require new, dedicated, high-speed double-track rail infrastructure within or paralleling the Shenandoah line.

Estimate of Feasibly Divertible Trucks Based on Business Strategy

The goal, essentially, is to create truck "express lanes" in the I-81 corridor -- but on rail, rather than on I-81 itself. The potential diversion opportunity is focused on long-haul truck trips entering and exiting Virginia on I-81. A total of 3,190 trucks per day of this

type have been identified (see Table 10). A service offering this speed would not be designed for short-haul service to Virginia origins and destinations; this would compromise its service speed, and over short distances its speed advantage compared to higher-speed open technology (Strategy #4) would be less significant. Strategy #5 would not be able to capture trucks that enter Virginia on I-77 or other routes, or leave via I-495/I-95 or other routes, because these origins and destinations are not proximate to the logical beginning and ending points (Knoxville and Harrisburg) for this service.

One way the service might generate demand is by operating as a “truck intercept,” capturing long-haul trucks between all origins and destinations and shifting their freight to rail for the duration of the trip through Virginia. This strategy turns conventional railroading on its head. For established intermodal services, a trucker brings freight to a nearby rail terminal and hands it off to the railroad; the railroad carries it to a distant rail terminal at a lower line-haul cost than trucking; and another trucker delivers it to a nearby destination. The goal is to minimize the distance by truck and maximize the distance by rail, thereby taking the greatest advantage of rail’s lower line-haul costs. In the “truck intercept” model, the trucker may drive a long distance over the road before getting to, or after departing from, Knoxville or Harrisburg. For a move between Knoxville and Harrisburg, rail would cover nearly all the distance (540 miles or so); for a move between Laredo and Northern New Jersey (around 1,970 miles) rail would cover a little over 25 percent of the distance. To be workable, such a service would have to offer the shipper, or the trucker, a compelling reason to hand off the cargo to the railroad for what might be a relatively small share of the end-to-end trip. Possible reasons might include:

- Lower end-to-end cost than the all truck option. This would have to take into account the cost of the rail service, less the cost savings from nine hours of driving eliminated. These figures have not yet been estimated.
- Greater ability to run loaded trucks in both directions. Once a trucker hands off freight at Knoxville or Harrisburg, he/she wants to pick up a return load as soon as possible. If volumes in this corridor are high enough, there may be good chances to match incoming truckers with outbound loads.
- Faster end-to-end speed than the all-truck option. The service speed will depend on two factors: line haul speed (how fast the train moves), load/unload time (which counts against end-to-end service time), and schedule frequency (since time spent waiting for train counts against end-to-end service time). The all-truck travel time is nine hours; a 120 mph service with a total load/unload/wait time of 1.5 hours could do the trip in six hours.
- Trucking becomes less attractive. For example, prohibitive tolls or burdensome operating restrictions might be put in place on I-81.

The other way the service might generate demand is by operating as a “truck shuttle.” This model is similar to the English Channel Tunnel. To get through the “Chunnel,” vehicles are loaded onto rail platforms and the rail platform moves them from one end to the other. An analogous operation would be for truckers on I-81 approaching the Virginia

state line to pull off into terminals at Knoxville or Harrisburg, load onto a train, stay with their trucks and be carried from one end of the State to the other by rail, then unload and continue on their way. Compared to the truck intercept approach, this has some advantages: it does not require the coordination of two different truck trips, one at either end; and it allows the driver to find a return load at the end point of his delivery, as he/she would normally do. The main drawback is the loss in productivity savings: instead of saving nine hours of drive time, the savings is the difference between the drive and train time. This would probably require a shuttle service to be priced lower than an intercept service.

Regardless of how it operates, this is an entirely new concept in U.S. railroading and there are no precedents for estimating the potential demand. Considerable further work would be needed to establish the price point and other important service parameters. For present purposes, however, we can make some reasonable approximations of the potential “upside” to this opportunity.

It is highly unlikely that any action, short of compulsion, would cause 100 percent of potentially eligible long-haul truck traffic to shift to rail. Today, there is a choice between truck and rail in this corridor, and most freight chooses truck; as long as a choice remains available, some freight will continue to choose truck, for reasons of service, or cost, or suitability to the origin-destination routing, or other factors.

We tested two possible demand scenarios. In Scenario 5A, the service is developed as a follow-on to Strategies #1 through #4, and captures 50 percent of the trucks that are not diverted by other Strategies. In Scenario 5B, the service captures 50 percent of the trucks that might conceivably use it, and no other strategies are developed.

Table 25. Estimates of Feasible Truck to Rail Diversion for Very High-Speed Truck Intercept/Truck Shuttle Service

Capture Scenario	Potentially Divertible Trucks/Day	Capture Rate	Feasibly Divertible Trucks/Day
Scenario 5A (50% Capture of Trucks Not Diverted by Other Strategies)			
Potentially Divertible (Long-Haul I-81 Only)	3,190		
Long-Haul I-81 Only Captured by Strategy #1	832		
Long Haul I-81 Only Captured by Strategy #2	416		
Long Haul I-81 Only Captured by Strategy #3	0		
Long-Haul I-81 Only Captured by Strategy #4	485		
Total	1,456	50%	728
Scenario B (50% Capture, No Other Strategies)	3,190	50%	1,595

The total cost estimated for the required work is \$9 billion dollars. This reflects 350 miles of new dedicated high-speed double track at \$20 million per mile in Virginia, plus \$1 billion in work in Pennsylvania and \$1 billion in work in Tennessee.

To achieve extremely high diversion rates, rail costs must be competitive with trucking. Given the high cost of developing the service, significant public investment would undoubtedly be needed, lest those costs be passed on to truckers. Also, if the service could not charge enough to cover its operating costs, the public sector would have to step in with operating subsidies in order to keep the service price in line with trucking, and maintain the high diversion rate. Potential subsidy costs have not been estimated.

Benefits and Costs

Strategy 5A would divert a minimum of 728 trucks per day, or 265,798 per year, in the base analysis year. This represents 22.8 percent of potentially divertible trucks, 12.8 percent of long-haul through trucks on I-81, 7.8 percent of total trucks on I-81, and 1.8 percent of total AADT on I-81. The total number of units diverted through the year 2035 is estimated at 11.0 million. With a total cost in Virginia of \$7.0 billion -- which could potentially be funded by some combination of private railroads, the Federal government, the Commonwealth, and users -- the cost in Virginia per diverted unit is \$632.02. The cost estimate assumes that Strategies #1, #2, #3, and #4 are already in place.

Table 26. Benefits and Costs of Strategy #5

Evaluation Factor	#5A	#5B
Potentially Divertible Trucks	3,190	3,190
Long-Haul through Trucks Diverted	728	1,595
Other Trucks Diverted	-	-
Total Trucks Diverted	728	1,595
Long-Haul through Trucks on I-81	5,711	5,711
Total Trucks on I-81	9,284	9,284
Total AADT on I-81	39,730	39,730
Share of Potentially Divertible Trucks Diverted	22.8%	50.0%
Share of Long-Haul Through Trucks Diverted	12.8%	27.9%
Share of Total Trucks Diverted	7.8%	17.2%
Share of Total AADT Diverted	1.8%	4.0%
Annual Units Diverted, 2008	265,798	582,175
Annual Units Diverted, 2035	560,229	1,227,065
Total Units Diverted, 2008-2035 (Millions)	11,075,635	24,258,859
Projected Cost Total (\$ Millions)	9,000	9,000
Projected Cost in Virginia (\$ Millions)	7,000	7,000
Cost in Virginia per Unit Diverted (\$)	632.02	288.55

Strategy 5B would divert a minimum of 1,595 trucks per day, or 582,175 per year, in the base analysis year. This represents 50.0 percent of potentially divertible trucks, 27.9 percent of long-haul through trucks on I-81, 17.2 percent of total trucks on I-81, and 4.0 percent of total AADT on I-81. The total number of units diverted through the year 2035 is estimated at 24.3 million. With a total cost in Virginia of \$7.0 billion -- which could

potentially be funded by some combination of private railroads, the Federal government, the Commonwealth, and users – the cost in Virginia per diverted unit is \$288.55. The cost estimate is independent of other Strategies.

Overall Feasibility Assessment

The truck intercept/truck shuttle service has the potential to divert significant numbers of trucks to rail – but only if the capture rates are extremely high, and only if no other strategies are employed to achieve truck to rail diversion, and only at an extremely high cost. The cost per diverted unit is higher for this strategy than for any other strategy evaluated in this report.

The concept would be a completely new idea in North American railroading, and would require substantially more analysis to conclusively determine feasibility, so its **feasibility is unknown** at this time.

Figure 31. Summary of Strategy #5

Strategy #5 aims to establish a very high-speed (perhaps 120 mph) open technology service between Knoxville and Harrisburg. Such a service might potentially attract intermodal and non-intermodal trucks that are passing through Virginia using I-81. These trucks could be “intercepted” (arriving trucks would hand off cargo to the railroad, and different trucks would pick up the freight at the other end of the line) or “shuttled” (arriving trucks and their drivers would be carried from one end of the line to the other, like a ferry boat on land). This would require new, dedicated, high-speed double-track rail infrastructure along or paralleling the Shenandoah line.	
Potentially divertible trucks	Up to 3,190 / day
Capture rate	Possibly feasible to divert 50% of long-haul through trucks using I-81 only. Amount captured would depend on whether other strategies are in place. Not feasible to capture 100% of potentially divertible trucks.
Feasibly divertible trucks	728 / day (Scenario 5A, where other Strategies are implemented) 1,595 / day (Scenario 5B, where no other Strategies are implemented)
Proposals	No current plans for this service.
Cost estimate	Unknown. We estimate \$7 billion to upgrade the Piedmont Line in Virginia to higher speed, plus \$2 billion for matching improvements in TN and PA.
Risk Factors	Market capture rate estimates are extremely speculative at this point, and depend on adoption of non-traditional logistics by truckers and shippers. We assume high rates of market capture that may not be realized in practice. Construction costs are unknown and subsidies may be required in order for the service to be priced competitively with trucking. Environmental review not yet performed. Delivery of anticipated benefits not guaranteed. Requires funding of improvements in other states.
Key Findings	The feasibility of this strategy is unknown.

■ 3.8 Summary of Maximum Feasible Diversion

Comparison of Strategies

The preceding sections of this report evaluated five truck to rail diversion strategies:

- Strategy #1 – Expand Conventional Intermodal Rail (cost in Virginia of \$26.82 per diverted unit through 2035)
- Strategy #2 – Introduce Multistate Network of Open Technology Terminals (cost in Virginia of \$26.17 per diverted unit through 2035)
- Strategy #3 – Develop and Enhance Intermodal and Open Technology Terminals in Virginia (cost in Virginia of \$28.22 per diverted unit through 2035)
- Strategy #4 – Introduce Higher-Speed Open Technology (cost in Virginia of \$125.00 per diverted unit through 2035)
- Strategy #5 -- Implement Very High-Speed Truck Intercept/Truck Shuttle Service, Scenarios 5A (cost in Virginia of \$632.02 per diverted unit through 2035) and 5B (cost in Virginia of \$288.55 per diverted unit through 2035)

Diversion Program Evaluations

Each strategy was evaluated separately and estimates of its maximum feasible diversion, cost, and overall feasibility were prepared. Strategies #1 and #5B can be developed independent of any others, but Strategies #2, #3, #4, and #5A depend on the implementation of preceding strategies. It is therefore necessary to evaluate the diversion opportunities in terms of programs that represent combinations of strategies.

- **Strategy #1 alone** diverts 13.5 percent of I-81 trucks, estimated at 19.1 million units through 2035, at a Virginia-only capital construction cost of \$512 million, or \$26.82 per unit. Total capital cost including other states is estimated at \$2.1 billion. This strategy is considered feasible.
- **Strategies #1 and #2** divert 20.3 percent of I-81 trucks, estimated at 28.6 million units through 2035, at a Virginia-only capital construction cost of \$762 million, or \$26.61 per unit. Total capital cost including other states is estimated at \$2.675 billion. This program is considered potentially feasible.
- **Strategies #1, #2, and #3** divert 22.8 percent of I-81 trucks, estimated at 32.2 million units through 2035, at a Virginia-only capital construction cost of \$862 million, or \$26.78 per unit. Total capital cost including other states is estimated at \$2.775 billion. This program is considered potentially feasible.

- **Strategies #1, #2, #3, and #4** divert 29.9 percent of I-81 trucks, estimated at 42.2 million units through 2035, at a Virginia-only capital construction cost of \$2.1 billion, or \$50.07 per unit. Total capital cost including other states is estimated at \$4.275 billion. The feasibility of this program is unknown, primarily because the market's acceptance of Strategy #4 cannot be determined without extensive further research. For this study we have allowed that Strategy #4 might have very high rates of market capture, but even so it has a capital cost of \$125.00 per diverted unit, compared with less than \$27.00 per diverted unit for Strategies #1, #2, and #3.
- **Strategies #1, #2, #3, #4, and #5A** divert 37.7 percent of I-81 trucks, estimated at 53.3 million units through 2035, at a Virginia-only capital construction cost of \$9.1 billion, or \$171.09 per unit. Total capital cost including other states is estimated at \$13.275 billion. The feasibility of this program is unknown -- further market research, engineering, and environmental work is needed.
- **Strategy #5B alone** diverts 17.2 percent of I-81 trucks, estimated at 24.3 million units through 2035, at a Virginia-only capital construction cost of \$7.0 billion, or \$288.55 per unit. Total capital cost including other states is estimated at \$9.0 billion. The feasibility of this program is unknown -- further market research, engineering, and environmental work is needed.

Table 27. Benefits and Costs from Combinations of Strategies

	1 Only	1+2	1+2+3	1+2+3+4	1+2+3+4 +5A	5B Only
Potentially Divertible Trucks	3,209	4,813	5,278	6,998	6,998	3,190
Long-Haul through Trucks Diverted	1,255	1,883	1,883	2,368	3,097	1,595
Other Trucks Diverted	-	-	233	405	405	-
Total Trucks Diverted	1,255	1,883	2,116	2,773	3,502	1,595
Long-Haul through Trucks on I-81	5,711	5,711	5,711	5,711	5,711	5,711
Total Trucks on I-81	9,284	9,284	9,284	9,284	9,284	9,284
Total AADT on I-81	39,730	39,730	39,730	39,730	39,730	39,730
Share of Potentially Divertible Trucks Diverted	39.1%	39.1%	40.1%	39.6%	50.0%	50.0%
Share of Long-Haul Through Trucks Diverted	22.0%	33.0%	33.0%	41.5%	54.2%	27.9%
Share of Total Trucks Diverted	13.5%	20.3%	22.8%	29.9%	37.7%	17.2%
Share of Total AADT Diverted	3.2%	4.7%	5.3%	7.0%	8.8%	4.0%
Annual Units Diverted, 2008	458,075	687,295	772,340	1,012,319	1,278,117	582,175
Annual Units Diverted, 2035	965,496	1,448,629	1,627,881	2,133,690	2,693,920	1,227,065
Total Units Diverted, 2008-2035 (Millions)	19.1	28.6	32.2	42.2	53.3	24.3
Projected Cost Total (\$ Millions)	2,100	2,675	2,775	4,275	13,275	9,000
Projected Cost in Virginia (\$ Millions)	512	762	862	2,112	9,112	7,000
Cost in Virginia per Unit Diverted (\$)	26.82	26.61	26.78	50.07	171.09	288.55
Assessment of Feasibility	Feasible	Potentially Feasible		Feasibility Unknown		

Figure 32. Comparison of Truck to Rail Diversion Percentages

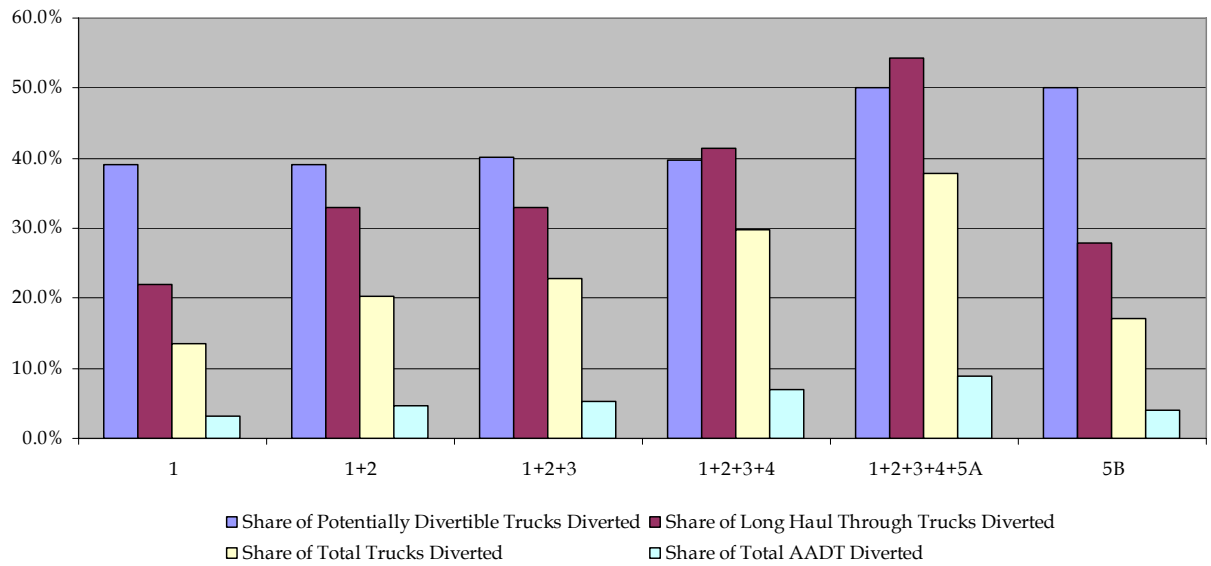


Figure 33. Total Units Diverted Through 2035 and Capital Costs in Virginia

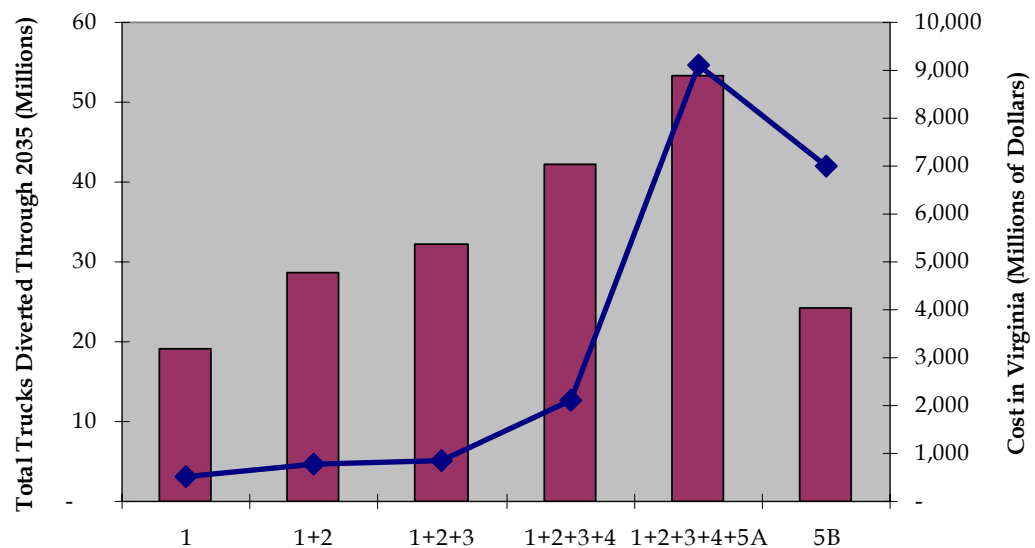
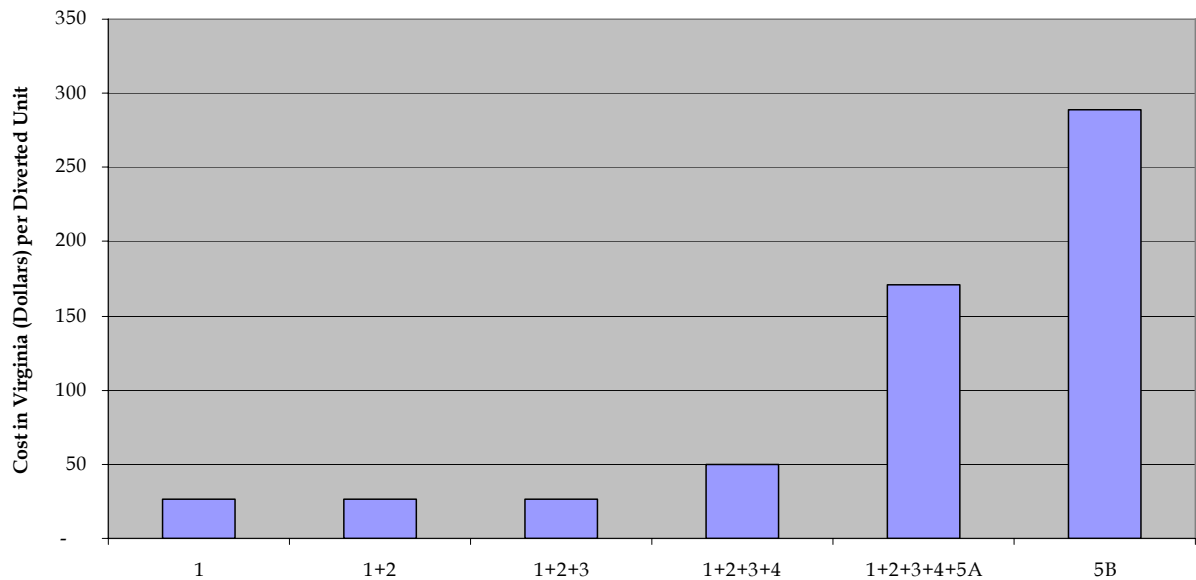


Figure 34. Cost in Virginia per Diverted Unit Through 2035



From among these choices, the preferred strategy may vary depending on which decision factor is most important. For example, Strategies #1 through #5A combined provide the highest truck to rail diversion, but at 7 times the cost per unit of Strategies #1 through #3 combined. No strategy, or combination of strategies, would divert more than 55 percent of long-haul through trucks, or 38 percent of total trucks, on I-81.

4.0 Action Plan to Achieve the Maximum Feasible Diversion

■ 4.1 Recommendations and Action Plan

This report recommends pursuing each of these strategies, but in different ways.

- Strategy #1 (improve conventional intermodal rail) is the most feasible, and there is an active proposal (the Crescent Corridor) to accomplish the targeted diversion. It is the lowest-risk strategy and one of the least expensive on a per unit diverted basis. The Commonwealth should continue to participate in the investigation and advancement of this concept.
- Strategies #2 (develop multistate open technology network) and #3 (develop and enhance Virginia terminals) are considered potentially feasible. From a technical and engineering standpoint the required improvements are achievable, but as service strategies they are by no means proven, and there are no active plans to implement them. They are inexpensive on a per unit diverted basis. NS should continue research of these strategies to increase truck to rail diversion over and above what can be accomplished using Strategy #1 alone.
- Strategy #4 (higher-speed open technology service) and Strategy #5 (very high-speed truck intercept/truck shuttle service) would further increase the truck to rail diversion potential. However, the feasibility of these strategies from a technical, market, and financial standpoint is currently unknown, and would require extensive and potentially costly follow-on studies to determine with specificity. Additionally, the anticipated capital cost in Virginia per diverted unit is quite high -- \$175 per unit for Strategy #4 and \$288 per unit for Strategy #5 -- compared to less than \$27 per unit for Strategies #1, #2, and #3. Further investigation of these concepts may be warranted, but should be a lower priority than advancement of the more proven and cost-effective strategies identified in this report.

The recommended action plan to achieve the maximum feasible truck to rail diversion in Virginia's I-81 corridor can be summarized as follows:

- **RECOMMENDATION #1: Advance the Crescent Corridor.** The Commonwealth should proceed with further investigations of potential participation in the Crescent Corridor project. These should include: evaluation of the Commonwealth's financial participation; structures to ensure successful investments by other states and the

private sector; necessary environmental studies; and agreements to ensure that the expected diversion benefits are actually delivered.

- **RECOMMENDATION #2: Investigate other potentially feasible truck to rail diversion strategies.** NS should proceed with further development of strategies to improve upon the diversion achieved by the Crescent Corridor, particularly from: a) conventional speed open technology service to divert long-haul bulk trucks; and b) potential private investments in Virginia terminals to divert Virginia origin-destination traffic.
- **RECOMMENDATION #3: Continue to advance improvements identified in the I-81 Tier I EIS.** The EIS estimated a maximum diversion of 1,224,500 units in 2035; this study finds that it is feasible divert 965,496 annual units in 2035, and potentially feasible to divert up to 1,627,881 units. The difference between the diversion estimate in this report and the diversion estimate in the EIS represents slightly more than two years of normal growth in the total number of I-81 trucks, which is not considered significant.

■ 4.2 Issues Related to the Crescent Corridor Program

Questions and Concerns

This report finds that the Crescent Corridor program, as formulated by Norfolk Southern, would effectively capture the full diversion opportunity associated with Strategy #1, expand conventional intermodal rail. During the course of this study, a number of questions were raised regarding the Crescent Corridor proposal. Some of these are addressed below; others will undoubtedly arise as the project continues to advance.

- **How accurate is Norfolk Southern's traffic estimate?** NS based its market estimates on historic trends and feedback from its customers regarding potential future service, and on detailed rail network operations modeling by Woodside Associates, a consulting firm specializing in such modeling. Acting independently, and using a completely different methodology, Cambridge Systematics identified a comparably sized diversion opportunity.
- **Would all of the truck to rail diversion cited by NS be from I-81?** The most recent diversion data, which is drawn from documents and research supporting the NS application for a Federal "TIGER" grant, addresses each Virginia highway separately. The diversion estimates cited in this report are for I-81 only. The Crescent Corridor also would divert trucks from other Virginia routes, including I-77, I-495/I-95, and I-66; but none of that data is included in this report, and none of the associated benefits to the Commonwealth are cited.

- **Does the NS Crescent Corridor proposal capture all of the trucks that could be feasibly diverted from I-81?** No. it does not. This report identifies four other strategies that would address other diversion opportunities.
- **Could more capacity be provided by running intermodal trains seven days a week, rather than six?** NS envisions running trains six days per week rather than seven. In theory, the rail network could handle more traffic by running trains on the seventh day as well. However, most customers do not work a seventh day, so containers and dry vans would tend to accumulate in NS's railyards awaiting pickup, creating congestion and possibly requiring additional storage area.
- **What projects within the Crescent Corridor program yield the most “bang for the buck?”** NS modeling suggests the Crescent Corridor improvements work best as a package. Follow-up value engineering studies could consider the effects and benefits of individual projects and combinations of projects.
- **Are improvements needed on both the Piedmont and Shenandoah lines, or could improvements be consolidated on a single line?** South and west of Virginia, these two lines serve substantially different geographies and markets. Both the NS traffic estimates and the CS estimates of divertible trucks are based on serving both of these “market sheds.” In theory, traffic from both lines could be combined over either the Piedmont or the Shenandoah lines using either or both of the lines (Lynchburg-Roanoke, Manassas-Front Royal) that connect the two routes. Combining traffic would certainly result in increased travel times and possibly increased service costs for traffic routed off its “least distance” path, due to increased route mileage. It also might trigger the need for more intensive investments in the Lynchburg-Roanoke and Manassas-Front Royal connectors, and would likely accelerate the need to develop the Culpeper cutoff (see discussion below). The operational impacts, market effects, and costs associated with single-line improvement options need to be addressed by rail operations modeling.
- **What other rail network improvements might be needed in Virginia?** The Culpeper Cutoff is a concept that should be on the radar screen. It would involve construction of a new double track railroad, engineered for 60 mph intermodal train speeds, between Culpeper (on NS's Manassas-Charlottesville line) and near Linden (on NS's Manassas-Front Royal line). At 36 miles in length, the Cutoff would reduce the distance traveled of each Crescent Corridor-Piedmont route train by over 38 miles and reduce running time by more than an hour. Shenandoah route trains using the Cutoff would incur a few more miles in distance, but save running time. The Cutoff – or a comparable infusion of new capacity – will be necessary long term to accommodate NS traffic growth beyond 2035, and it might be needed sooner if I-81 Corridor traffic is consolidated on either the Piedmont or Shenandoah lines.
- **What are the real costs of the NS Crescent Corridor projects, both within and outside of Virginia?** The cost of Crescent Corridor projects in Virginia is estimated at \$512 million; the cost in other states is estimated at \$1.6 billion.

- **What happens if Virginia Phase I and Phase II projects are implemented, but supporting investments in other states are not?** Does Virginia gain value from those projects, or is the value lost? Failure to secure investments in other states will impact the amount of traffic handled over the Corridor, affecting the number of trucks that would be diverted from I-81. This could be addressed in more detail by risk analyses.

Public-Private Partnership Opportunities

The Commonwealth regularly engages in public-private partnerships to secure rail improvements with clearly demonstrable public benefits. For the Crescent Corridor, several types of partnership structures could be explored:

- **Sole Commonwealth ownership.** This is not a realistic option. The lines are a critical part of the NS network and are not for sale; and if they were offered for sale the price would far exceed the planned cost of the Crescent Corridor improvements.
- **Shared ownership of the improved portions of the Corridor.** In this structure, the Commonwealth would obtain an ownership stake in the new Crescent Corridor infrastructure. CS understands that NS is not interested in this arrangement. CS sees it as problematic, because it establishes a for-profit relationship with one private transportation carrier, which could be seen as conflicting with the Commonwealth's public duties.
- **Loan agreement.** In this structure, the Commonwealth contributes a certain share of capital funding as a loan, to be repaid from railroad revenues based on additional traffic over a specified period of time. In other states, railroads have imposed traffic surcharges on their customers to help retire the public debt.
- **Guaranteed performance contract.** In this structure, the Commonwealth provides funding for the Crescent Corridor projects in the form of grants rather than loans. In exchange, the railroad guarantees the Commonwealth a minimum level of performance and resulting public benefit. General performance contracts also could be combined with loan agreements.

Benefit-Cost Analyses

The Commonwealth should undertake appropriate benefit/cost analyses to determine the levels and types of public benefit that would be generated. From this information, the Commonwealth should then determine the appropriate level of its participation in the project. There are several tools available for these analyses, including the Virginia DRPT Rail Enhancement Fund Benefit Model, as well as benefit/cost analyses prepared for NS in support of its TIGER application.

Multi-State Partnership

The Commonwealth should work with other states and Federal partners to identify and secure the funding commitments necessary to complete the full Crescent Corridor program, to guarantee that investments in Virginia yield the identified public benefits.

The Commonwealth and other states along I-81 have formed a “Corridor Coalition” to investigate and coordinate on issues of mutual interest and opportunity. Funding for the Crescent Corridor and other truck to rail diversion strategies is likely to be addressed by this group. The Commonwealth also has partnered with four other states in cosponsoring the Federal TIGER grant application submitted by NS.

Environmental Review

The Commonwealth, at the appropriate time, should ensure that required environmental investigations are undertaken.

■ 4.3 Issues Related to the I-81 Tier I EIS

The diversion analysis from the *I-81 Corridor Improvement Study* considered five scenarios: no-build (truck performance deteriorates, rail performance remains constant); limited improvements from Manassas to Front Royal (providing modest improvements in rail speed and reliability); additional limited improvements to the NS Piedmont line, including open technology; further improvements to the NS Piedmont line; and additional improvements to the NS Shenandoah line, including open technology. It estimated diversion using the U.S Department of Transportation’s Intermodal Transportation and Inventory Cost (ITIC) model, based on detailed assumptions about changes in truck and rail speed, cost, and reliability. However, the analysis was limited to Virginia projects. The estimated diversion was between 107,000 and 1,224,000 truck trips annually in year 2035. From Table 27, our year 2035 diversion estimates are as follows:

- From **feasible** strategies (Strategy #1 only): 965,496 truck trips; and
- From **potentially feasible strategies** (Strategies #2 and #3): 662,385 truck trips.

Based on feasible and potentially feasible strategies only, this report estimates a potential diversion of between 965,496 and 1,627,881 truck trips annually in year 2035. This is somewhat higher than the *I-81 Corridor Improvement Study*, as might be expected given that we considered the potential for multistate improvements. However, it is not much higher, due to the effects of the current economic downturn.

The difference between the *I-81 Corridor Improvement Study* high forecast and our high forecast for year 2035 is 403,881 truck trips. This is not seen as a significant difference. By the year 2035, truck traffic on I-81 will be growing by nearly 200,000 truck trips per year

(see Table 4 and Table 29), so the difference represents only a little more than two years of truck traffic growth on I-81.

■ 4.4 Conclusion and Next Steps

This report identifies and quantifies the maximum feasible truck-to-rail diversion potential in Virginia's I-81 Corridor. It confirms the potential for truck to rail diversion to make a significant contribution to freight movement in Virginia's I-81 Corridor. It identifies a range of potential strategies for physical, operational, and technological improvements to the rail network in Virginia and in other states, including several strategies considered feasible or potentially feasible.

As immediate next steps, the following recommendations are offered:

- RECOMMENDATION #1: Advance the Crescent Corridor.
- RECOMMENDATION #2: Investigate other potentially feasible truck to rail diversion strategies.
- RECOMMENDATION #3: Continue to advance improvements identified in the I-81 Tier I EIS.